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ENRICHMENT STATUS OF OWEN SOUND BAY, TOBERMORY HARBOUR AND THIRTEEN LAKES IN GREY AND BRUCE COUNTIES

1975 - 1976

Ministry of the Environment
Ontario

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ENRICHMENT STATUS

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AND THIRTEEN LAKES

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1977

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SUMMARY

In general, the 13 lakes sampled in the Southwestern Region had low to moderate Secchi disc and chlorophyll a readings, the latter reflecting limited production of planktonic algae. Tobermory Harbour and Owen Sound Bay, had high Secchi disc readings (good water clarity) and low to moderate chlorophyll a values.

From 1974 to 1975, significant increases in chlorophyll a concentrations (up to 200 percent) were noted for all lakes and bays, with the exception of Tobermory Harbour, indicating a higher production of planktonic algae. However, even with this increased production, the results for 1975 still reflect lakes of relatively low productivity. Generally, these increases in chlorophyll a were accompanied by decreases in Secchi disc readings. However, Tobermory Harbour and Owen Sound Bay exhibited increases in Secchi disc readings while readings in Miller Lake remained constant.

All lakes for which data were available for comparison purposes showed an increase in Secchi disc readings for 1976. This was not always accompanied by a corresponding decrease in concentrations of chlorophyll a.

The lakes of Grey and Bruce counties do not closely adhere to the accepted chlorophyll a - Secchi disc relationship based on data collections from the rest of the Province. Due to low chlorophyll a and low to moderate Secchi disc values, data points consistently fall below the typical chlorophyll a - Secchi disc curve.

The lakes are marl lakes and exhibit typical characteristics such as high alkalinities and heavy depositions of marl. The lakes are shallow and because of N. E. - S. W. axial orientation most are subject to wind-induced turbidities caused by the resuspension of the loose marl bottom sediments. Such resuspension is believed to account in part for the low Secchi disc readings. The lakes are located in a limestone area with very little surrounding soil cover and have small drainage basins.

Diatomaceous scums were often the most common form of visible plant growth, along with bulrushes, both inhabiting the more protected and more stable littoral zone. The algae Chara spp were common in the deeper water areas of most lakes.

INTRODUCTION

Over the past few years an increasing concern for problems of pollution in recreational lakes has materialized as a result of accelerated cottage development. Many individual cottagers, cottage associations and permanent shoreline residents have requested that complete water quality evaluations be carried out to assess the degree of pollution in various lakes throughout the Province. Exhaustive physical, chemical, bacteriological and biological evaluations for large numbers of lakes are beyond the financial and logistical capabilities of personnel involved in water management programmes, and in light of recent studies, are not necessary in order to classify the quality of recreational waters. Appendix C provides a brief explanation of water quality problems in recreational lakes.

In 1971 a relatively simple but effective evaluation programme was carried out on 12 recreational lakes in the Province of Ontario. The programme, which involved the collection of data on water clarity and algal populations, was highly successful owing to the efforts of local residents, cottagers, marina and resort owners, and personnel of the Ministry of Natural Resources and the Ministry of the Environment. The success of the programme was exemplified by the fact that in 1972 the number of lakes sampled increased from 12 to 35. The following year 91 lakes were sampled in Southern Ontario, and in 1974, 98 lakes were sampled.

In the Southwestern Region, considerable support in sampling selected lakes has been provided to the Ministry of the Environment by the North Grey-Sauble Valley Conservation Authorities. Investigations outlined in this report have been carried out on Owen Sound Bay, Tobermory Harbour and 13 inland lakes throughout the period 1972 to 1976. Table 1 lists the names and locations of the bodies of water and Figure 1 indicates their geographic distribution.

Table 1: Locations of Tobermory Harbour, Owen Sound Bay and 13 lakes in Bruce and Grey counties sampled during 1975 and 1976.

Lake	Location
Bass	Keppel Twp., Grey County
Berford	Albemarle Twp., Bruce County
Boat	Amabel Twp., Bruce County
Cameron	St. Edmunds Twp., Bruce County
Chesley	Amabel Twp., Bruce County
Gillies	Lindsay Twp., Bruce County
Gould	Amabel Twp., Bruce County
Isaac	Albemarle Twp., Bruce County
McCullough	Sullivan Twp., Grey County
Miller	Lindsay Twp., Bruce County
Owen Sound Bay	Sydenham Twp., Grey County
Pearl	Brant Twp., Bruce County
Sky	Albemarle Twp., Bruce County
Tobermory Harbour	St. Edmunds Twp., Bruce County
Wilcox	Artemesia Twp., Grey County

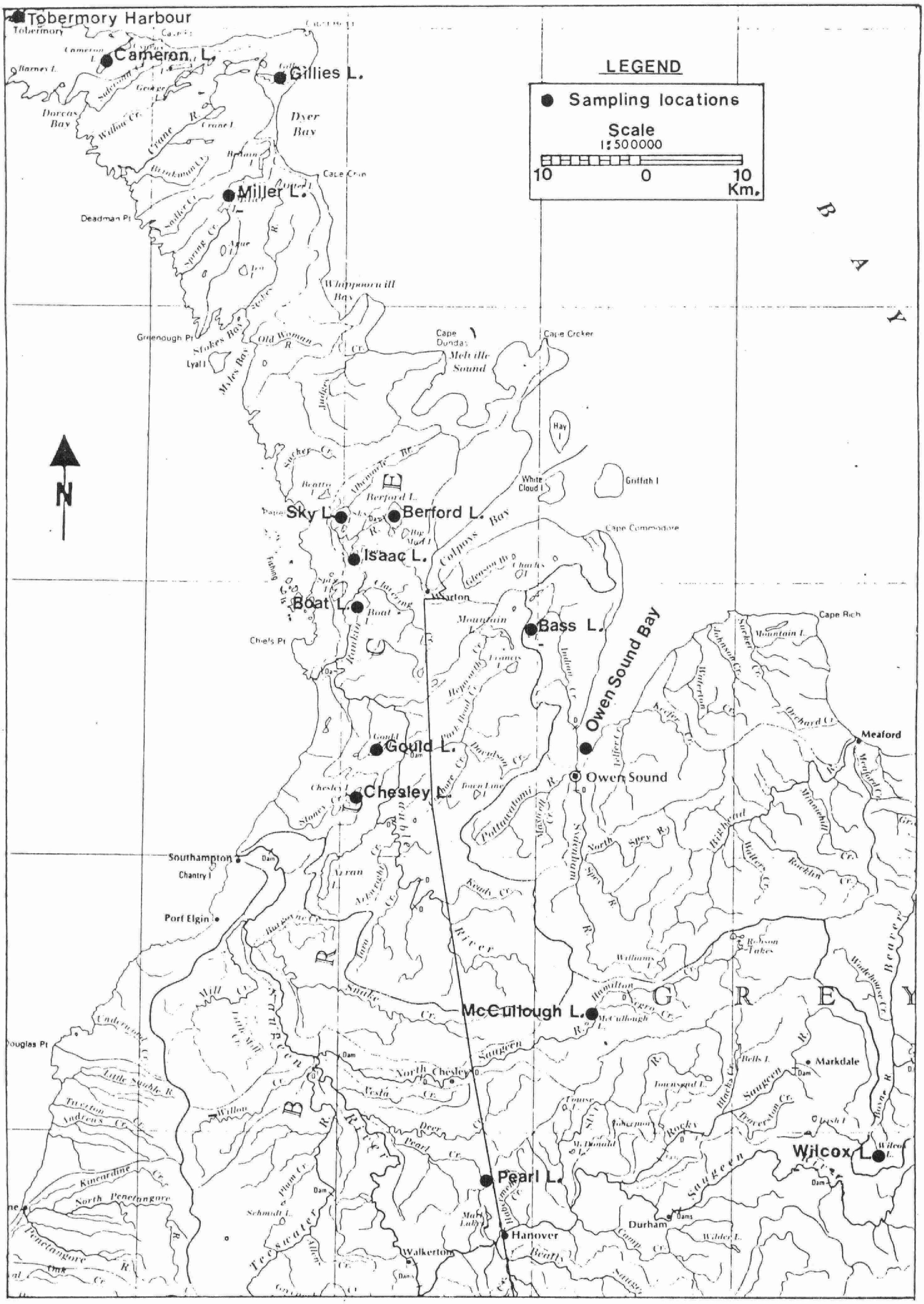

FIGURE 1 - The location of Tobermory Harbour, Owen Sound Bay and 13 lakes in Grey and Bruce counties sampled during the summers of 1975 and 1976.

METHODS

Water clarity, which governs the depth of light penetration into a lake, is one of the most important parameters used in defining water quality and can be measured using a Secchi disc. The disc, having a diameter of 8 inches (20 centimeters), is divided into black and white alternating quadrants and is lowered into the water on a graduated line until the quadrants cannot be distinguished. The depth is noted and the disc is raised slowly until the quadrants are just visible, at which point the depth is again noted. The average of these two depths is termed the Secchi disc reading. As depicted in Figure 2, Secchi disc readings are substantially greater in lakes having low phytoplankton (microscopic freefloating algae) numbers than in lakes characterized by high algal densities and excessive vascular aquatic plant growth. Secchi disc readings were taken weekly during the summers of 1975-1976 in the deepwater zones of the 15 bodies of water.

Chlorophyll a is a photosynthetic green pigment in algae and its concentration is used as a rough indication of the extent of biological activity in a lake at the time of sampling since it is regulated by all of the combined physical, chemical and biological factors which affect algal production. Chlorophyll a samples were taken on each visit to the lakes by lowering a narrow-mouthed bottle (32 ounce capacity) to the approximate location of the 1% incident light level, or through the zone of effective algal production known as the euphotic zone. The extent of this zone was determined by doubling the value of the Secchi disc reading (Figure 2). The speed of lowering and raising the bottle was regulated so that the bottle was just filled when it reached the surface; the object being to collect a composite water sample from all depths of the measured water column. Ten to 15 drops of a 2% magnesium carbonate suspension were immediately added to each sample to stabilize the chlorophyll a pigment. Following delivery to the Ministry of the Environment's laboratory facilities in Toronto, the samples were filtered using 1.2 micron filter papers, wrapped in aluminum foil to prevent light from reaching the residue, refrigerated and analyzed by staff of the Ministry's Laboratory Services Branch.

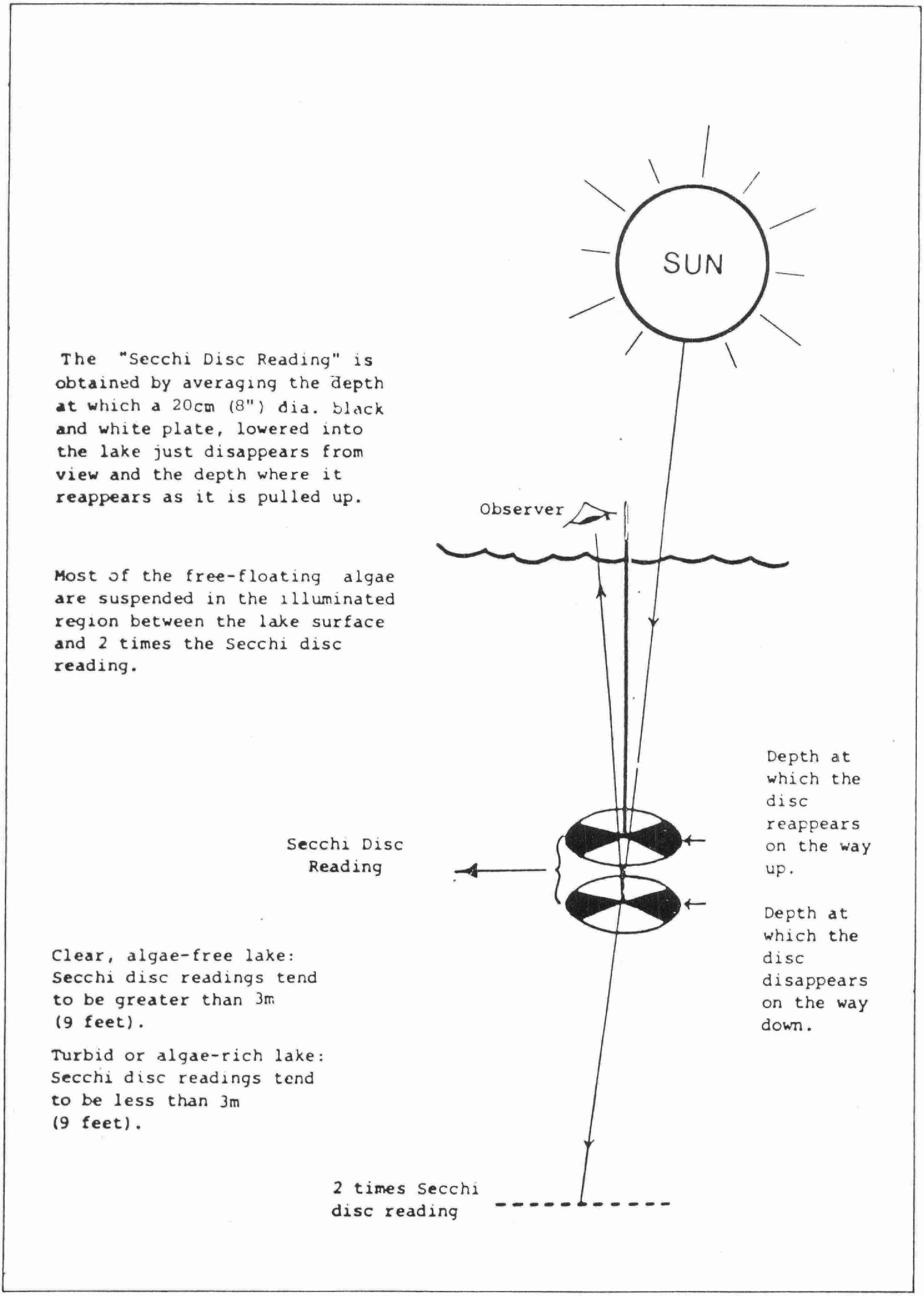

FIGURE 2 - Diagram illustrating the use of a Secchi disc to measure water clarity.

RESULTS AND DISCUSSION

Secchi disc readings indicate the depth to which light penetrates into a lake and chlorophyll a is a photosynthetic green pigment in algae. Since light penetration is affected by algal cells suspended in the water, a good correlation should exist between the depth to which light penetrates and the amount of chlorophyll a in lakes of varying degrees of enrichment, assuming that colour and suspended particulate materials (other than algae) interfere minimally with light transmission. Scientists have noted that a "near hyperbolic" relationship exists between Secchi disc readings and chlorophyll a concentrations. The curve in Figure 3 depicts this relationship for 3549 sets of data collected from 220 lakes in the Province. Oligotrophic (nutrient poor) waters having a low chlorophyll a production and corresponding greater light penetration lie along the vertical axis of the hyperbola, while points for eutrophic or highly enriched lakes are characterized by high chlorophyll a concentrations and poor water quality and thus are situated along the horizontal limb.

Data for mesotrophic (medium productivity) lakes are dispersed about the middle section of the curve. Distribution of the data for the inland lakes of Grey and Bruce counties is shown in Figure 4.

Mean Secchi disc, chlorophyll a and acidified chlorophyll a values for Tobermory Harbour, Owen Sound Bay and 13 lakes in Grey and Bruce counties are presented in Table 2, while individual measurements for 1976 and a graphical presentation of data (1972 to 1976) are presented in Appendices A and B, respectively.

Commencing in 1974, acidified chlorophyll a was analysed, in addition to the usual chlorophyll a analysis. Acidified chlorophyll a is a measure of the concentration of chlorophyll a in living algal cells, and is a more accurate approximation of the density of algae which are actively growing and reproducing in the water. Any chlorophyll a concentration measured which is in excess of the acidified chlorophyll a concentration is that portion found in dead or dying algal cells which are still suspended in the euphotic zone at the time of sampling. These results are shown in Table 2, along with the acidified chlorophyll a to chlorophyll a ratio expressed as a percentage. It is pointed out that the data represent conditions in June, July, and August only, and therefore the presence or absence of heavy algal growths in the early spring and/or fall cannot be confirmed. In the long term, acidified chlorophyll a measurement may replace chlorophyll a measurement as it is a better approximation of the planktonic biomass supported by a lake.

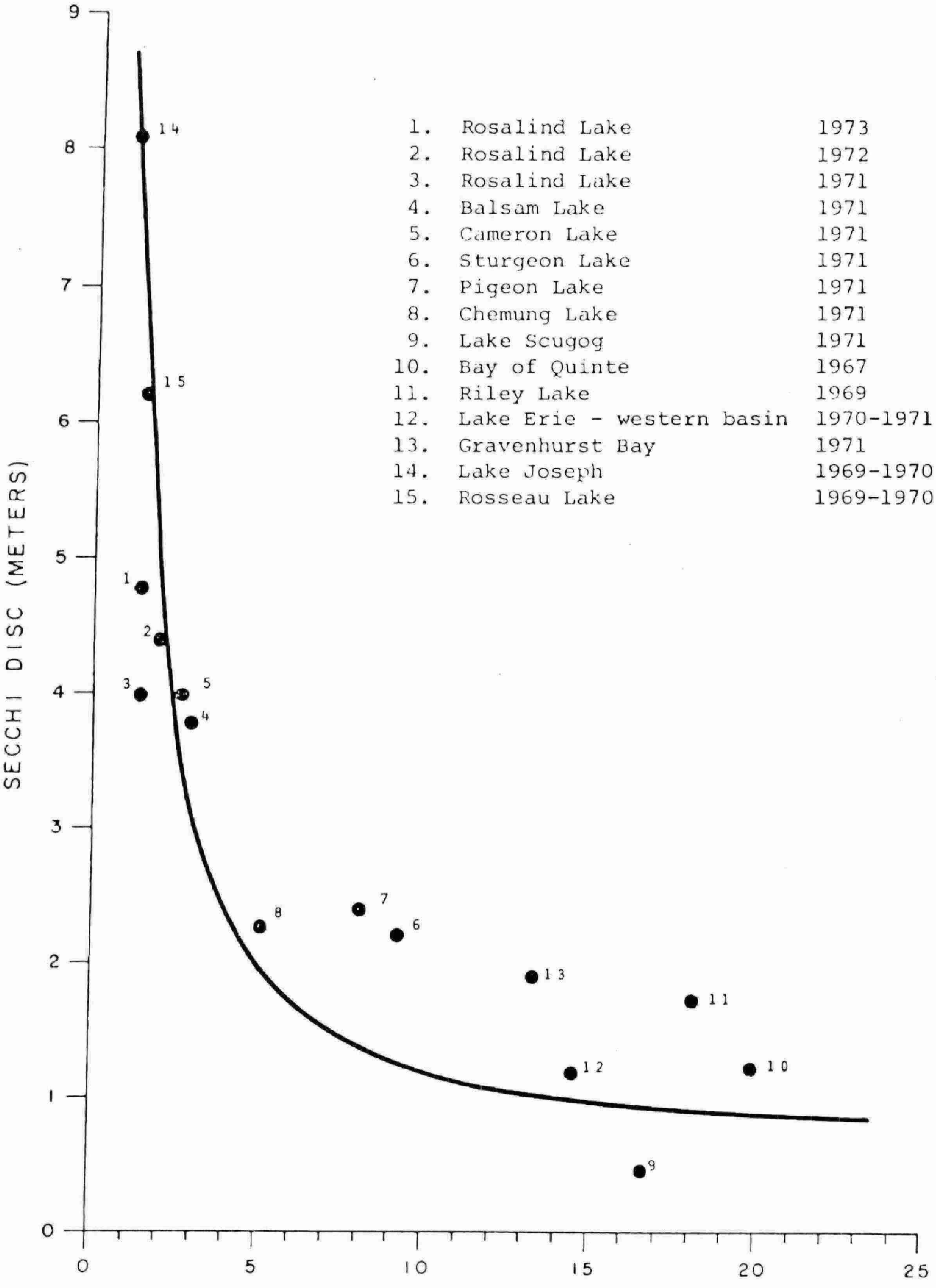

FIGURE 3 - Typical chlorophyll a - Secchi disc relationship for lakes in the Province of Ontario.

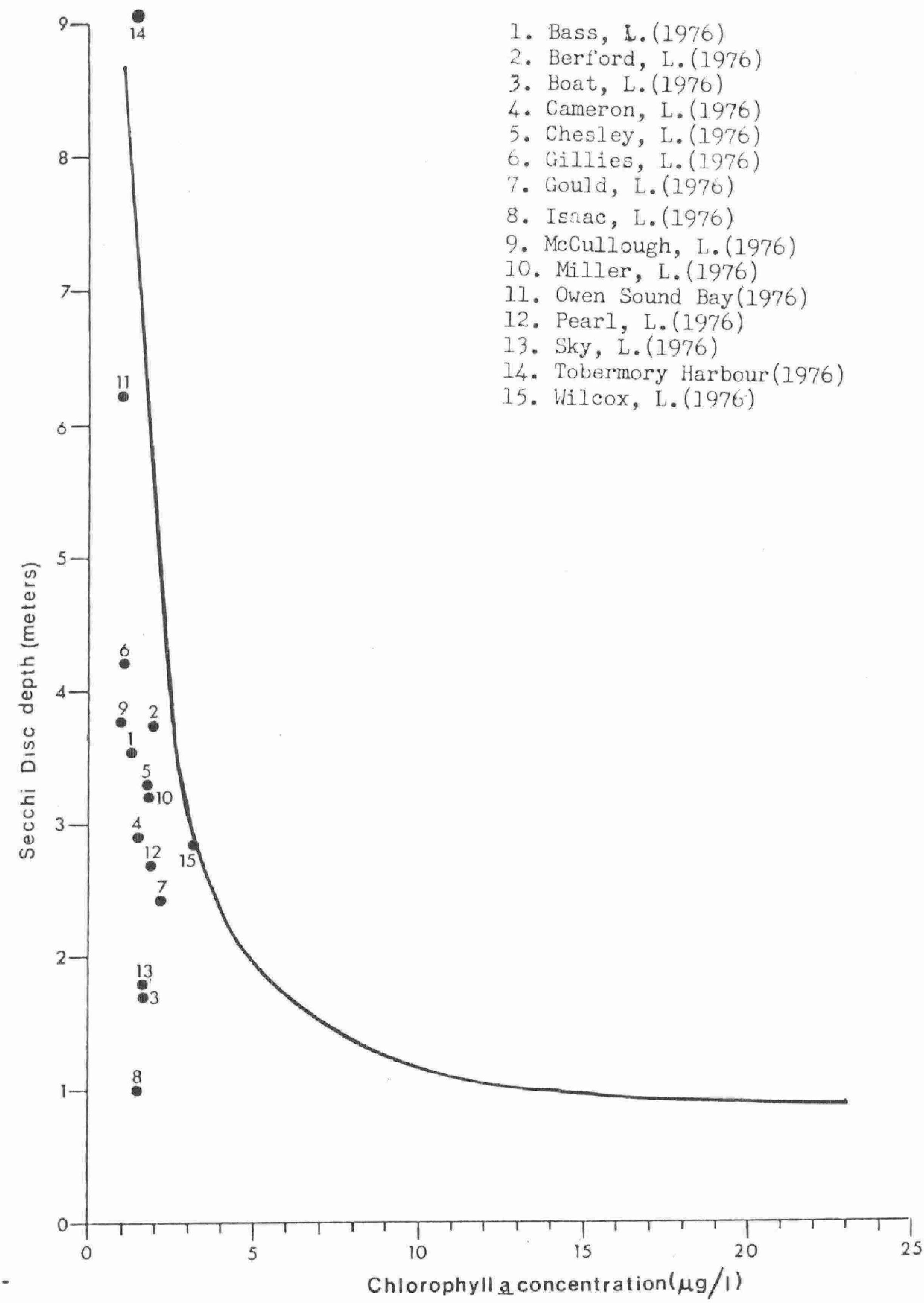

FIGURE 4 - Positions of Tobermory Harbour, Owen Sound Bay and 13 lakes in Grey and Bruce counties sampled during the summer of 1976 on the chlorophyll a - Secchi disc curve.

In Boat, Isaac and Sky lakes the Secchi disc was visible on the lake bottom and Berford Lake and Tobermory Harbour were too shallow to collect samples through twice the Secchi disc depth. Consequently, composite water samples in these cases were collected through the column of water extending from the surface to approximately 0.5 meters above the bottom. Individual graphs showing mean values are not included in Appendix B for Gillies, Gould, Pearl and Wilcox Lakes as 1976 was the first year data were gathered from these lakes. Instead, these data are presented on a single graph for comparison purposes.

In general, all waters sampled in 1975, (except Tobermory Harbour) showed an increase in plankton production based on chlorophyll a data. Percentage increases in chlorophyll a from 1974 to 1975 were: Isaac Lake (222%), Miller Lake (87%), Sky Lake (83%), Boat Lake (54%), McCullough Lake (40%), Bass Lake (38%), Berford Lake (36%), and Cameron Lake (17%). Tobermory Harbour exhibited a decrease in chlorophyll a of 14%. Notwithstanding these higher values, conditions in 1975 still reflected relatively low production of planktonic algae by provincial standards.

These percentage increases in chlorophyll a concentrations were accompanied by corresponding decreases in Secchi disc readings of 40% for McCullough, 28% for Chesley, 22% for Bass, 8% for Berford, and 50% for Cameron Lake. No meaningful comparison is available for Boat, Isaac, and Sky lakes because the Secchi disc was visible on the lake bottom. Tobermory Harbour and Owen Sound Bay showed increased Secchi disc readings of 10 and 14%, respectively, while Miller Lake remained the same at 2.3 meters.

Table 2: Summary of the mean values for Secchi disc and chlorophyll a data collected from Owen Sound Bay, Tobermory Harbour and 13 lakes in Grey and Bruce counties during the summers of 1972-1976. Acidified chlorophyll a concentrations are given as percentages of the total chorophyll a concentrations.

Lake	Year	Secchi disc (m)	Chlorophyll a (ug/l)	Acidified chlorophyll a (ug/l)	Acidified a/ Total chlorophyll a (%)
Bass	1976	3.5	1.2	0.8	63
	1975	1.7	1.1	0.8	67
	1974	2.2	0.8	0.6	75
	1973	2.8	1.0		
Berford	1976	3.7	1.9	1.1	58
	1975	3.3	1.5	0.9	60
	1974	3.6	1.1	0.7	60
	1973	3.2	1.7		
Boat	1976	Bottom	1.7	1.3	77
	1975	(1.1-1.7)	2.0	1.2	60
	1974		1.3	0.9	63
	1973		1.1		
Cameron	1976	2.9	1.4	1.0	46
	1975	1.8	1.4	1.0	72
	1974	1.9	1.2	0.8	66
	1973	2.7	1.4		
Chesley	1976	3.3	2.0	1.0	48
	1975	2.3	3.6	1.7	47
	1974	3.2	1.6	1.0	64
	1973	3.0	1.7		
	1972	3.1	2.5		
Gillies	1976	4.3	1.0	0.6	60
Gould	1976	2.4	2.4	1.8	75
Isaac	1976	Bottom (0.9-1.8)	1.5	0.9	59
	1975	Bottom (0.9-1.8)	2.9	1.9	66
	1974	0.9	0.9	0.7	73

McCullough	1976	3.7	1.1	0.8	73
	1975	2.6	1.4	0.9	64
	1974	4.3	1.0	0.6	60
	1973	4.2	1.5		
Miller	1976	3.2	2.1	1.3	62
	1975	2.3	2.8	1.5	54
	1974	2.3	1.5	1.0	70
	1973	2.8	2.2		
	1972	2.5	1.8		
Owen Sound Bay	1976	6.2	1.0	0.8	88
	1975	5.5	0.6	0.4	67
	1974	4.8	0.4	0.2	50
Pearl	1976	2.7	2.0	1.4	70
Sky	1976	Bottom (1.4-1.8)	1.5	0.9	61
	1975	Bottom (1.4-1.8)	2.2	1.6	73
	1974	1.6	1.2	0.9	75
	1973	1.0	1.8		
Tobermory Harbour	1976	9.1	1.4	0.6	43
	1975	5.5	0.6	0.3	50
	1974	5.0	0.7	0.4	57
Wilcox	1976	2.8	3.4	2.1	62

Data for 1976, however, showed a marked increase in Secchi disc readings for all waters relative to 1975. Bass Lake showed the highest percentage increase in Secchi disc visibility (105%), followed by Tobermory Harbour (65%), Cameron Lake (61%), Chesley Lake (43%), McCullough Lake (42%), Miller Lake (39%), Owen Sound Bay (13%), and Berford Lake (12%). Changes in Secchi disc readings were not calculated for Boat, Isaac and Sky Lakes as the Secchi disc was visible on the bottom.

Accompanying these increases in Secchi disc readings were corresponding decreases in chlorophyll a for Isaac (48%), Chesley (44%), Sky (32%), Miller (25%), McCullough (21%), and Boat Lakes (15%).

Chlorophyll a values increased in 1976 for Tobermory Harbour (133%), Owen Sound Bay (67%), Berford Lake (27%) and Bass Lake (9%) while Cameron Lake remained constant at 1.4 ug/litre. As in 1975, production of planktonic algae in 1976 was still low by provincial standards.

CONCLUSIONS

As shown by the graphs presented in Appendix B the lakes in Grey and Bruce counties do not follow the accepted chlorophyll a - Secchi disc relationship for most waters in the Province. Typically the lakes have low chlorophyll a concentrations with low to moderate Secchi disc visibilities and constantly fall below the curve that expresses the usual chlorophyll a - Secchi disc relationship.

This means that the lakes are low in planktonic plant biomass. Some of the lakes however are exhibiting other signs of enrichment (e.g. Chesley Lake).

Accounting, at least in part, for the low levels of planktonic algae in the 13 lakes is the dominance of other plant forms which include diatomaceous scums, the alga Chara and rooted plants such as bulrushes. From field observations and from complaint investigations, a significant increase in rooted plant growth has been noted in some lakes. An increase in water milfoil (*Myriophyllum spp*) is being observed closely.

The results of data from the Regional "Self-Help" Programme from 1972 to 1976 show oscillations in water quality with no consistent trends yet developed. These types of oscillations probably reflect responses of these small lakes to natural annual variations such as the amount of insolation (solar energy), quantity of precipitation and general weather conditions.

Owing to this sensitivity, additional chemical and biological information is being collected simultaneously with the chlorophyll a and Secchi disc measurements. It is anticipated that these additional data will result in a better understanding of the limnology of the individual lakes in Grey and Bruce counties. Such an understanding will enable Ministry staff to better assess their capacity for development and to provide a basis for preserving the existing water quality. The "Self-Help" Programme should be continued over several years until a firm baseline is established for individual lakes that will subsequently permit an analysis of trends in water quality through periodic re-assessments.

ACKNOWLEDGEMENTS

We gratefully acknowledge the assistance of Mr. Larry Roszell of the North Grey - Sauble Valley Conservation Authorities for his co-operation and support in collecting samples for this programme. We also thank the members of the Pearl Lake Cottagers' Assocation and Wilcox Lake Cottagers' Association who collected samples for their respective lakes, and Mr. John Westwood and Mr. Brad Bowman for their invaluable assistance in the many aspects of this programme.

APPENDIX A

Secchi disc, chlorophyll *a* and acidified chlorophyll *a* data collected from Owen Sound Bay, Tobermory Harbour and 13 lakes in the Grey and Bruce counties during the summers of 1975 and 1976.

BASS LAKE

			Chlorophyll a (ug/l)	Acidified chlorophyll a (ug/l)	Secchi disc (m)
1975	July	3	0.7	0.1	1.7
		18	1.1	1.1	1.7
		23	2.0	1.5	1.4
		31	0.9	0.6	1.5
	Aug.	7	0.8	0.8	1.7
		14	1.5	1.2	1.8
		20	0.9	0.4	2.4
MEAN			1.1	0.8	1.7
1976	June	11	1.1	0.8	3.7
		18	1.1	0.7	---
	July	9	1.5	1.2	2.1
		23	0.9	---	2.6
		30	0.8	0.5	3.3
	Aug.	6	1.0	0.7	3.8
		11	0.9	0.2	2.9
MEAN			1.1	.7	3.5

BERFORD LAKE

		Chlorophyll a (ug/l)	Acidified chlorophyll a (ug/l)	Secchi disc (m)
1975	July 4	0.3	0.2	3.8
	11	1.1	0.5	3.0
	15	2.1	1.2	3.2
	22	1.9	1.1	4.5
	29	1.5	0.2	3.6
	Aug. 7	2.6	2.2	3.3
	12	2.7	2.2	---
	22	1.3	0.7	2.7
	Sept. 17	1.0	---	2.3
MEAN		1.5	0.9	3.3
1976	June 9	1.3	0.2	4.6
	18	0.8	0.4	3.3
	22	1.4	<0.1	3.9
	July 6	1.2	0.6	4.7
	13	2.8	2.1	3.6
	21	3.3	2.3	3.6
	27	2.9	---	2.3
	Aug. 16	1.6	1.0	3.8
MEAN		1.9	1.1	3.7

BOAT LAKE

			Chlorophyll a (ug/l)	Acidified chlorophyll a (ug/l)	Secchi disc (m)
1975	July	3	0.7	0.3	1.5 (B)
		4	0.9	0.6	1.4
		11	1.5	0.7	1.4 (B)
		15	3.4	1.8	1.2
		22	2.9	1.7	1.2
		29	1.8	0.9	1.2
	Aug.	8	1.8	1.5	0.8
		12	2.0	1.2	1.4 (B)
		22	2.8	2.3	1.4 (B)
MEAN			2.0	1.2	1.1
1976	June	9	1.3	1.1	2.0 (B)
		23	1.3	1.1	1.7
	July	8	0.9	0.7	1.8 (B)
		15	2.3	1.8	1.8 (B)
		22	1.7	1.0	1.7 (B)
	Aug.	5	2.8	2.2	1.5 (B)
MEAN			1.7	1.3	(B)

(B) - Secchi disc visible on lake bottom.

CAMERON LAKE

		Chlorophyll a (ug/l)	Acidified chlorophyll a (ug/l)	Secchi disc (m)
1975	July 2	0.5	0.2	2.1
	9	1.4	0.6	2.3
	14	1.6	1.1	1.8
	16	0.9	---	1.8
	17	1.5	0.8	2.0
	23	1.7	1.1	2.3
	30	1.8	1.2	1.2
	Aug. 6	1.0	0.8	0.9
	15	1.9	1.7	1.8
	20	2.0	1.4	1.7
	Sept. 15	1.5	---	1.8
MEAN		1.4	1.0	1.8
1976	June 10	1.0	0.9	2.1
	23	0.8	0.5	3.2
	28	1.0	0.8	4.8
	July 5	1.1	0.9	3.3
	19	2.4	1.5	2.7
	26	2.1	1.7	1.9
	Aug. 9	1.2	1.0	2.3
MEAN		1.4	1.0	2.9

CHESLEY LAKE

		Chlorophyll a (ug/l)	Acidified chlorophyll a (ug/l)	Secchi disc (m)
1975	July 11	1.7	1.0	2.6
	17	2.8	---	2.8
	19	2.0	1.0	2.7
	24	3.8	2.1	2.4
	Aug. 1	2.0	0.9	2.8
	6	3.2	2.2	2.1
	14	3.3	1.5	1.7
	21	4.3	2.9	1.8
	Sept. 17	9.4	---	1.1
MEAN		3.6	1.7	2.3
1976	June 6	3.1	---	3.5
	8	1.1	0.4	3.3
	22	2.2	2.0	3.3
	July 23	1.7	0.5	3.2
	30	1.8	0.9	3.8
	Aug. 12	1.9	---	2.6
MEAN		2.0	1.0	3.3

GILLIES LAKE

		Chlorophyll a (ug/l)	Acidified Chlorophyll a (ug/l)	Secchi Disc (m)
1976	June 10	0.8	0.3	4.8
	23	0.8	0.9	4.5
	30	1.6	0.8	4.5
	July 7	0.5	0.3	3.2
	14	1.3	1.1	2.9
	21	1.1	0.6	3.0
	28	0.8	0.6	4.5
	Aug. 11	0.9	0.1	6.5
MEAN		1.0	0.6	4.3

GOULD LAKE

		Chlorophyll a (ug/l)	Acidified Chlorophyll a (ug/l)	Secchi Disc (m)
1976	June 8	2.0	1.3	1.7
	22	1.1	0.9	2.0
	July 6	3.8	3.0	2.4
	20	3.3	2.4	3.0
	30	2.0	1.3	2.6
	Aug. 12	2.0	---	2.4
MEAN		2.4	1.8	2.4

ISAAC LAKE

			Chlorophyll a (ug/l)	Acidified Chlorophyll a (ug/l)	Secchi Disc (m)
1975	July	3	1.1	0.1	1.8 (B)
		10	2.9	2.4	1.8 (B)
		17	2.9	---	1.8 (B)
		24	3.0	2.2	1.5 (B)
		30	3.8	1.8	1.2 (B)
	Aug.	8	2.2	1.4	1.2 (B)
		14	3.3	2.6	0.9 (B)
		21	3.6	2.3	0.9 (B)
MEAN			2.9	1.9	(B)
1976	June	9	1.1	0.7	1.5 (B)
		23	1.8	1.0	1.4 (B)
	July	8	1.1	0.7	1.7 (B)
		22	1.5	0.5	1.5 (B)
	Aug.	5	2.1	1.5	---
MEAN			1.5	0.9	(B)

(B) - Secchi disc visible on lake bottom.

McCULLOUGH LAKE

			Chlorophyll a (ug/l)	Acidified Chlorophyll a (ug/l)	Secchi Disc (m)
1975	July	4	0.3	0.1	4.1
		11	1.6	1.2	2.9
		18	1.4	1.0	2.9
		24	1.5	0.9	2.3
	Aug.	1	0.9	0.4	2.4
		7	2.5	2.1	2.1
		14	1.0	0.3	2.3
		21	1.9	0.9	2.1
MEAN			1.4	0.9	2.6
1976	June	14	1.4	1.0	4.2
		22	0.7	0.4	3.3
		29	1.2	0.7	4.2
	July	23	0.6	<0.1	3.9
		27	1.6	---	3.8
	Aug.	12	1.3	0.2	2.9
MEAN			1.1	0.8	3.7

MILLER LAKE

		Chlorophyll a (ug/l)	Acidified Chlorophyll a (ug/l)	Secchi Disc (m)
1975	July 7	1.9	0.3	2.3
	14	3.8	---	2.9
	16	3.1	1.9	2.4
	21	3.3	2.6	2.3
	28	2.4	0.5	2.4
	Aug. 5	4.1	2.5	2.4
	15	2.2	1.9	2.6
	22	1.2	0.9	1.8
	Sept. 16	3.0	---	2.0
MEAN		2.8	1.5	2.3
1976	June 7	1.6	1.1	3.0
	21	1.0	0.7	3.6
	30	3.0	1.0	3.9
	July 7	1.6	1.3	3.2
	14	3.6	3.0	3.2
	21	2.4	1.5	3.0
	28	2.0	1.5	2.7
	Aug. 11	1.4	0.5	2.6
MEAN		2.1	1.3	3.2

OWEN SOUND BAY

			Chlorophyll a (ug/l)	Acidified Chlorophyll a (ug/l)	Secchi Disc (m)
1975	July	4	0.3	0.3	7.5
		11	0.4	0.4	5.3
		18	0.1	0.1	6.9
		24	1.0	0.5	5.4
	Aug.	1	0.4	0.3	6.9
		7	1.2	0.8	2.9
		15	0.7	0.4	3.9
MEAN			0.6	0.4	5.5
1976	June	1	1.9	1.9	5.7
		9	0.4	0.3	9.3
		11	2.7	1.8	5.7
		16	1.0	0.8	3.3
		18	0.5	0.2	7.2
		23	0.4	<0.1	5.7
		30	0.3	0.3	7.2
	Aug.	12	0.6	0.3	5.9
MEAN			1.0	0.8	6.2

PEARL LAKE

		Chlorophyll a (ug/l)	Acidified Chlorophyll a (ug/l)	Secchi Disc (m)
1976	June 13	4.2	3.1	4.0
	27	2.2	0.7	2.7
	July 4	2.0	1.0	3.1
	18	1.0	0.7	2.1
	25	1.0	0.6	1.7
	Aug. 1	1.2	0.8	1.7
	8	0.8	0.5	2.6
	5	1.1	1.2	2.7
MEAN		2.0	1.4	2.7

SKY LAKE

		Chlorophyll a (ug/l)	Acidified Chlorophyll a (ug/l)	Secchi Disc (m)
1975	July 3	1.5	---	1.8 (B)
	10	3.2	2.7	1.5 (B)
	17	2.2	---	1.1
	24	2.6	1.4	1.4 (B)
	31	1.6	1.0	1.5 (B)
	Aug. 8	1.9	1.4	1.5 (B)
	14	2.4	1.9	1.4 (B)
	22	2.3	1.3	1.4 (B)
MEAN		2.2	1.6	(B)
1976	June 9	1.5	1.0	1.5 (B)
	23	0.8	0.6	1.5 (B)
	July 8	1.1	0.7	1.8 (B)
	15	2.5	1.2	1.5 (B)
	22	1.6	0.9	1.8 (B)
	Aug. 5	1.4	1.1	1.5 (B)
MEAN		1.5	0.9	(B)

(B) - Secchi disc visible on lake bottom.

TOBERMORY HARBOUR

		Chlorophyll a (ug/l)	Acidified Chlorophyll a (ug/l)	Secchi Disc (m)
1975	July 7	0.1	---	5.4
	14	0.5	---	5.6
	21	0.7	0.2	7.5
	28	0.8	0.3	5.4
	Aug. 5	0.7	0.4	4.5
	11	0.6	0.4	6.0
	18	0.8	0.3	4.2
MEAN		0.6	0.3	5.5
1976	June 7	1.0	0.8	7.5
	21	0.7	0.5	7.2
	28	0.6	0.4	9.0
	July 5	0.6	0.5	10.5
	12	0.8	0.8	7.5
	19	5.0	1.5	9.0
	26	0.4	0.2	5.7
	Aug. 9	0.4	0.3	15.2
MEAN		1.4	0.6	9.1

WILCOX LAKE

		Chlorophyll a (ug/l)	Acidified Chlorophyll a (ug/l)	Secchi Disc (m)
1976	June 2	3.9	2.6	4.1
	13	2.4	1.2	2.1
	21	2.0	1.9	2.8
	27	3.3	2.3	2.8
	July 11	3.7	2.8	2.8
	18	3.6	2.9	2.5
	25	0.8	0.7	2.7
	Aug. 2	3.7	2.6	2.8
	22	3.4	2.2	2.8
MEAN		3.4	2.1	2.8

APPENDIX B

Chlorophyll *a* - Secchi disc relationships for Owen Sound Bay, Tobermory Harbour and 13 lakes in Grey and Bruce counties for the periods of record.

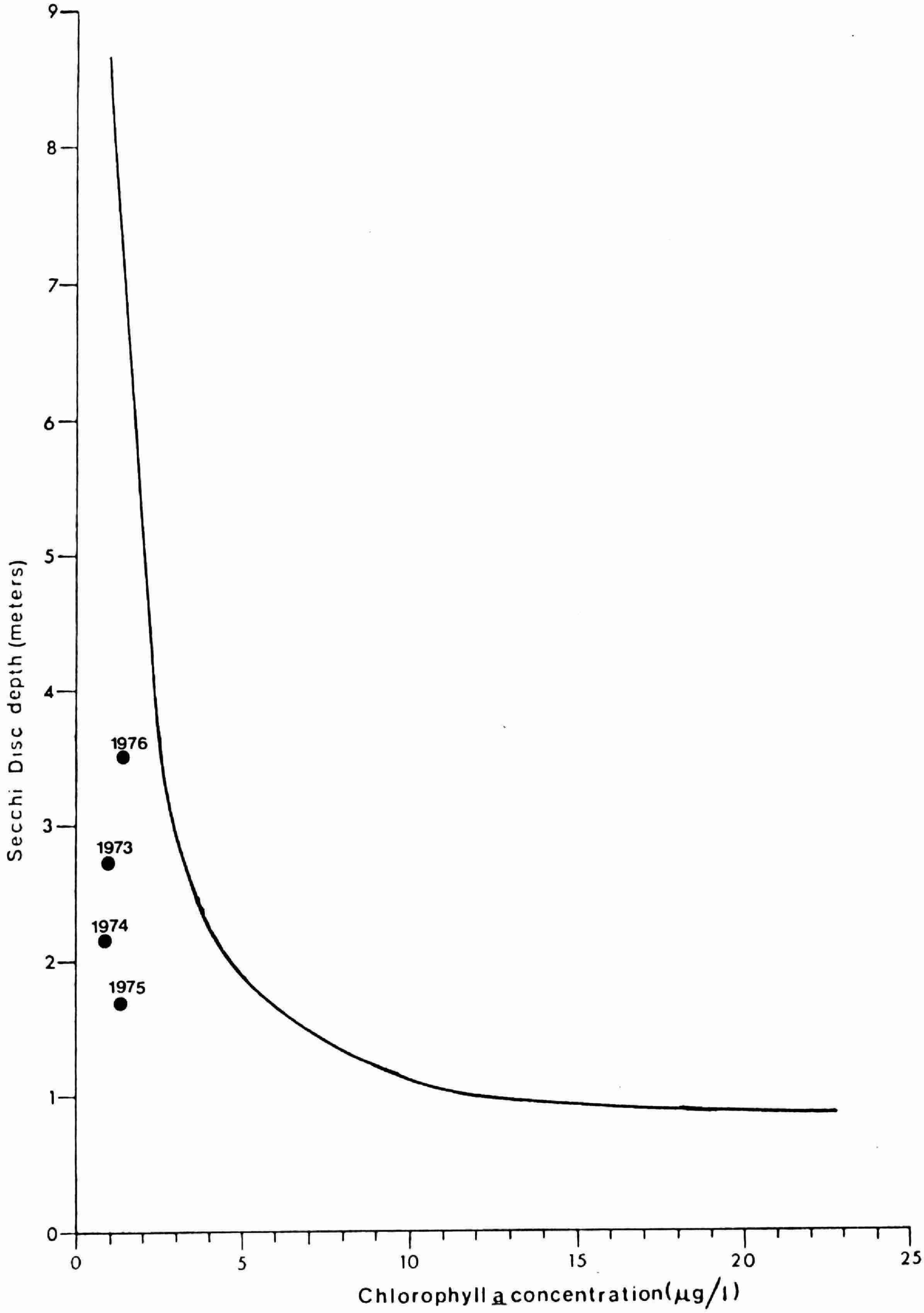

Figure1–Bass Lake

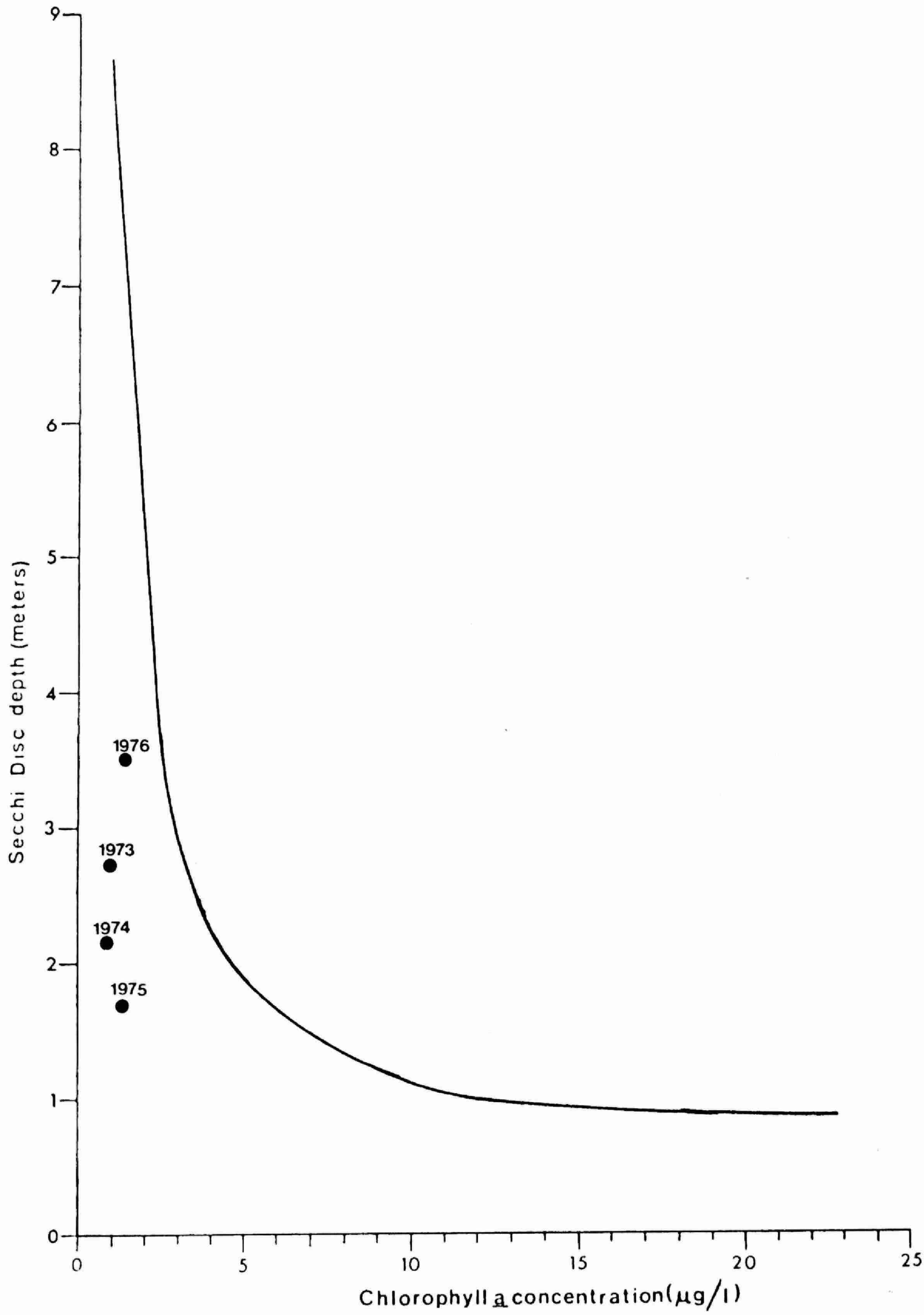

Figure1– Bass Lake

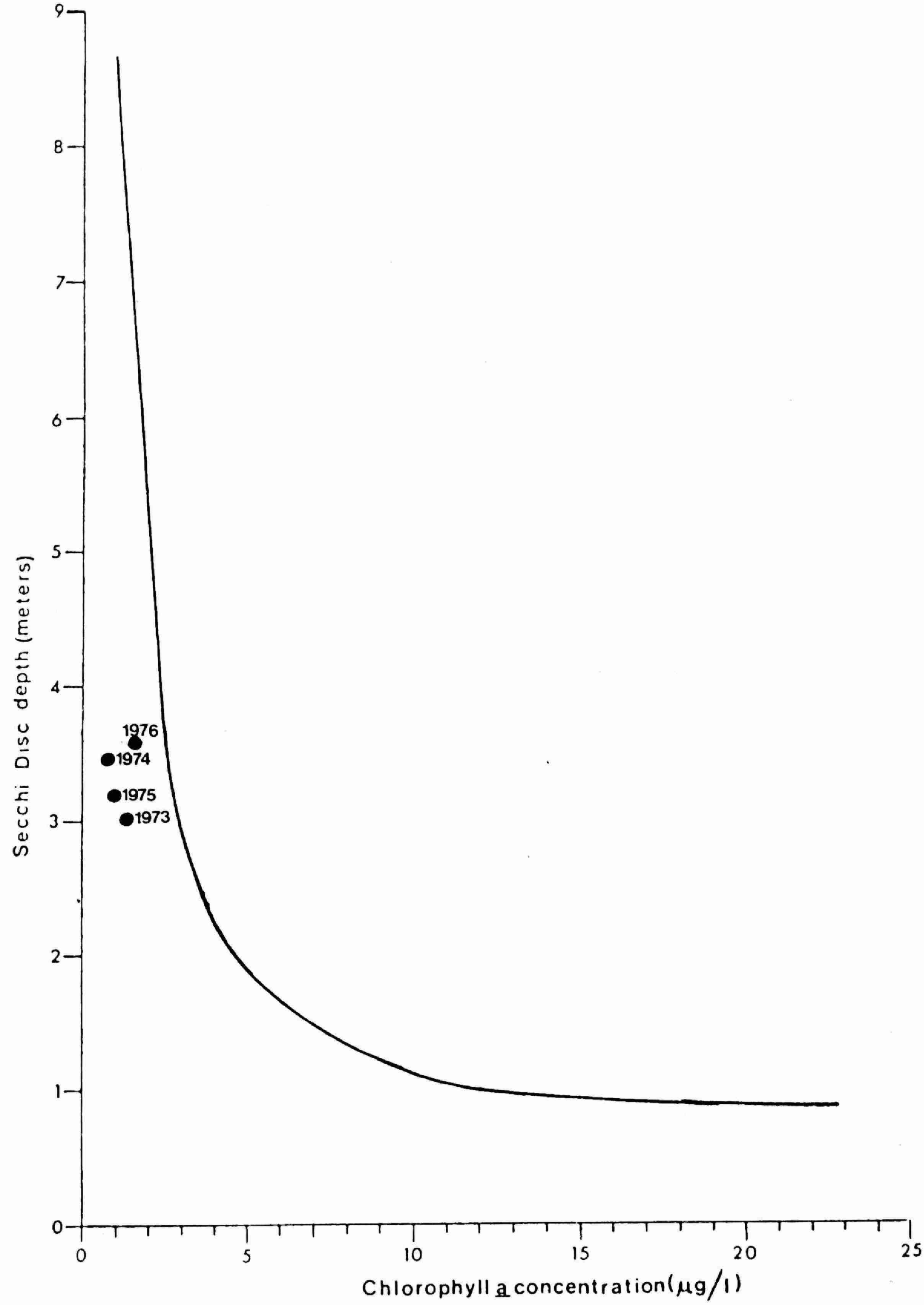

Figure 2-Berford Lake

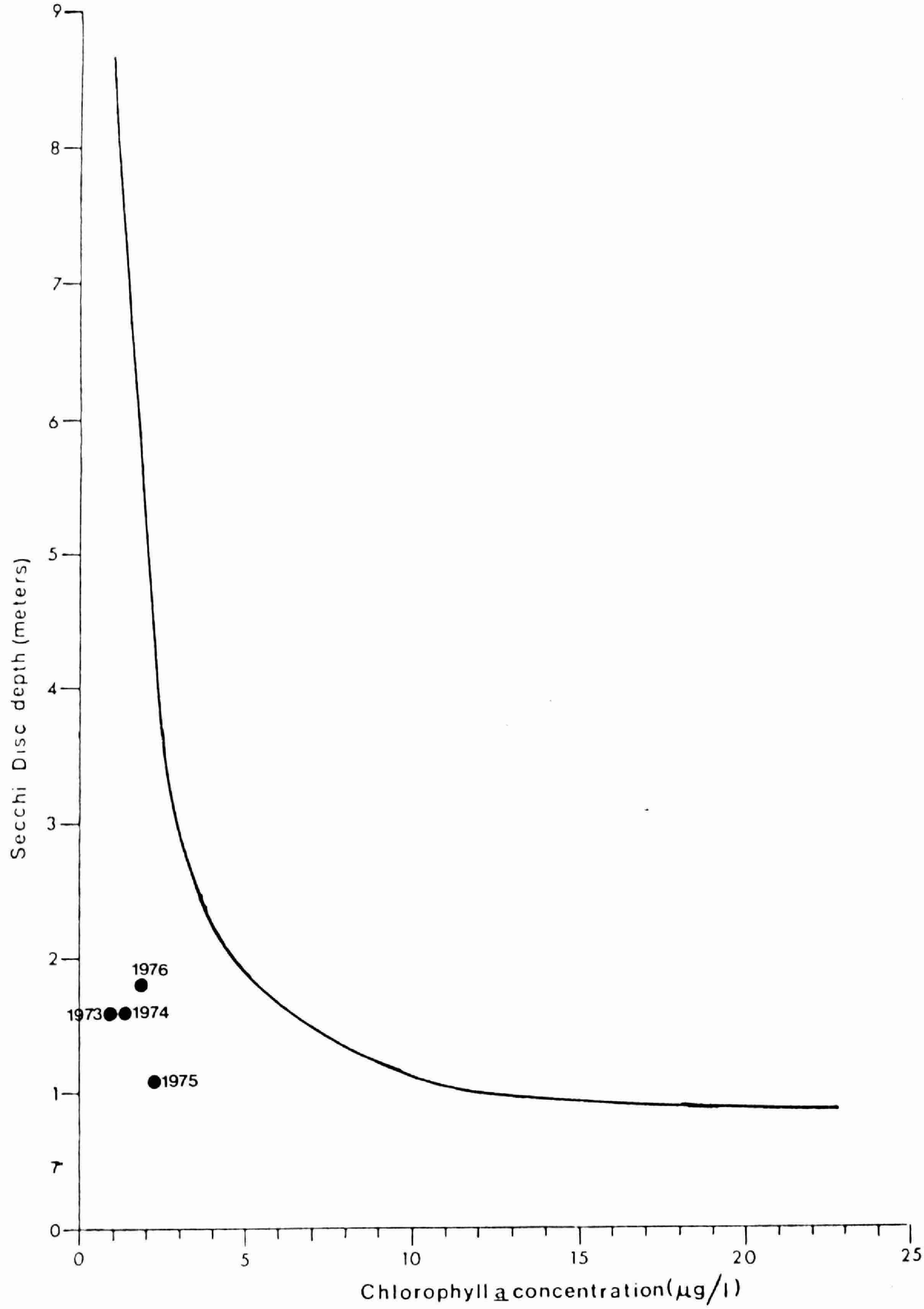

Figure 3-Boat Lake

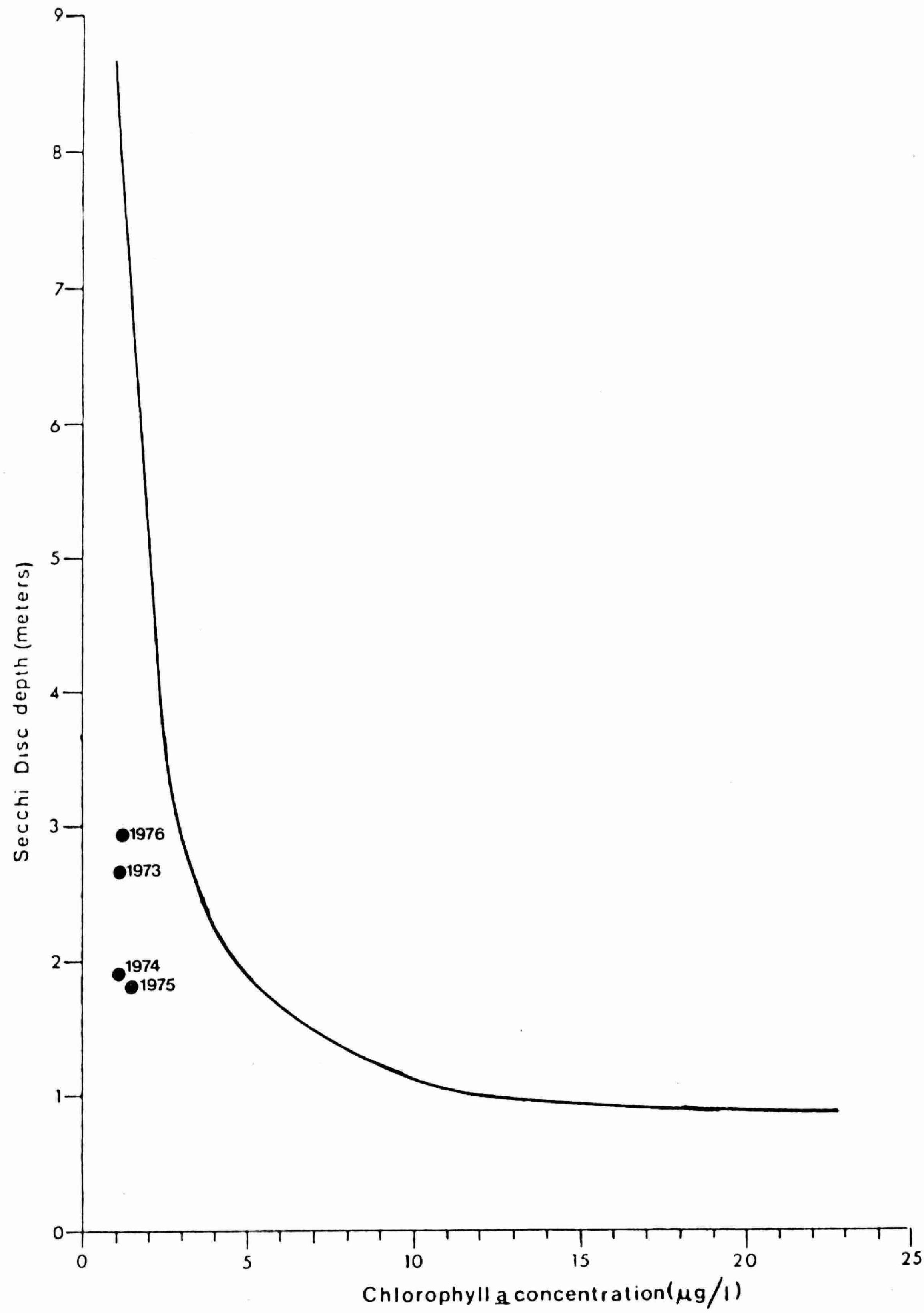

Figure 4 – Cameron Lake

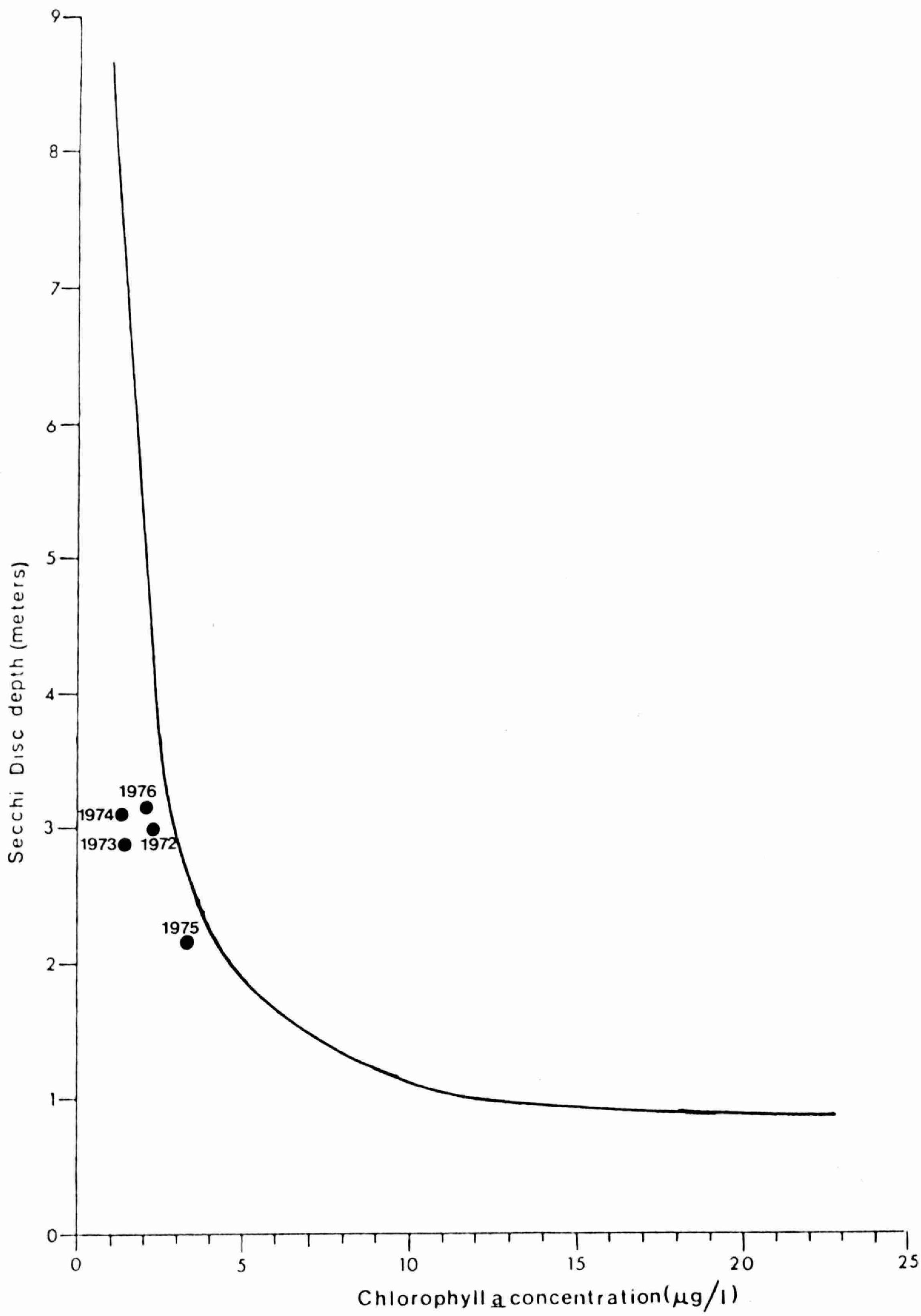

Figure 5-Chesley Lake

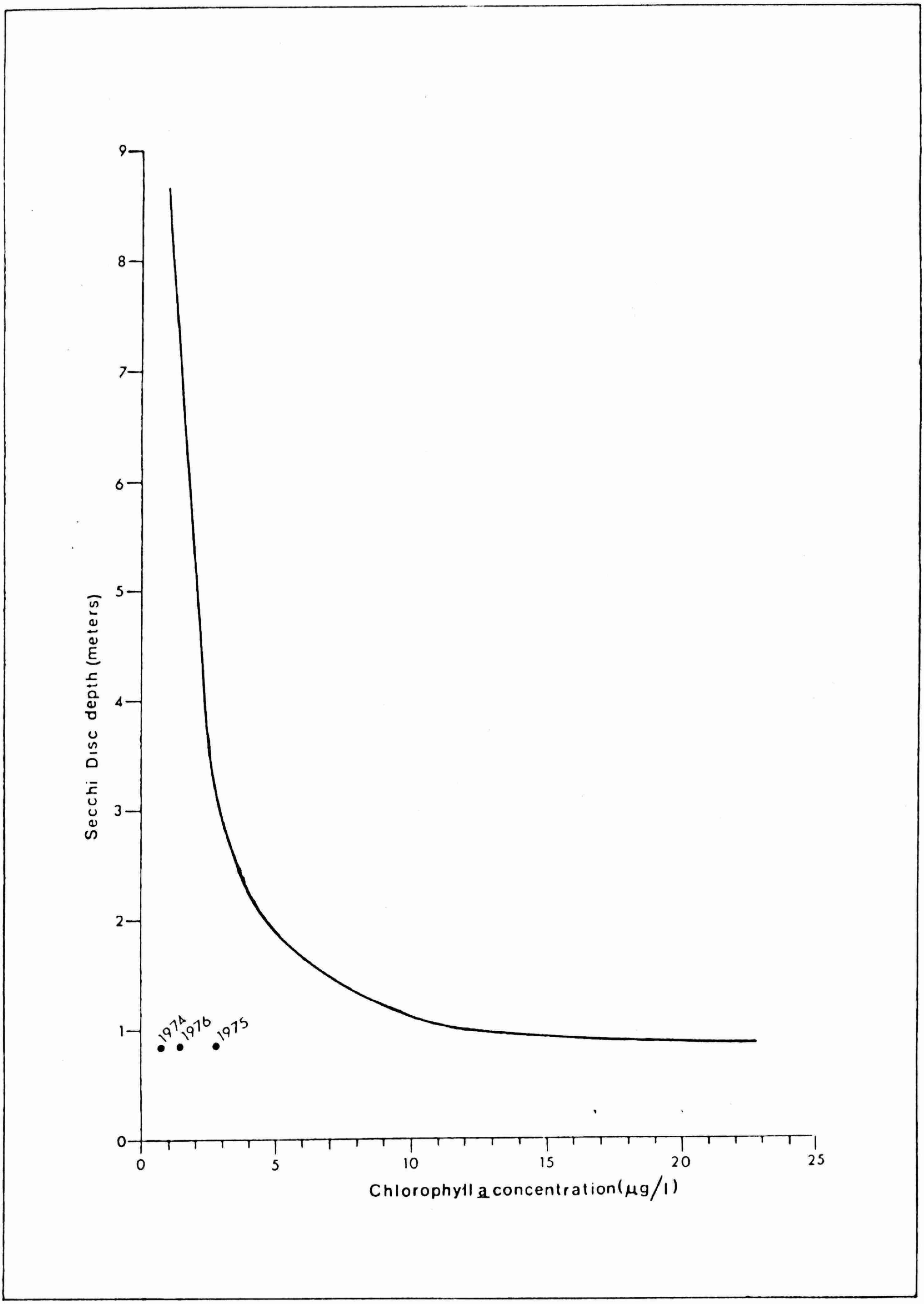

Figure 6—Isaac Lake

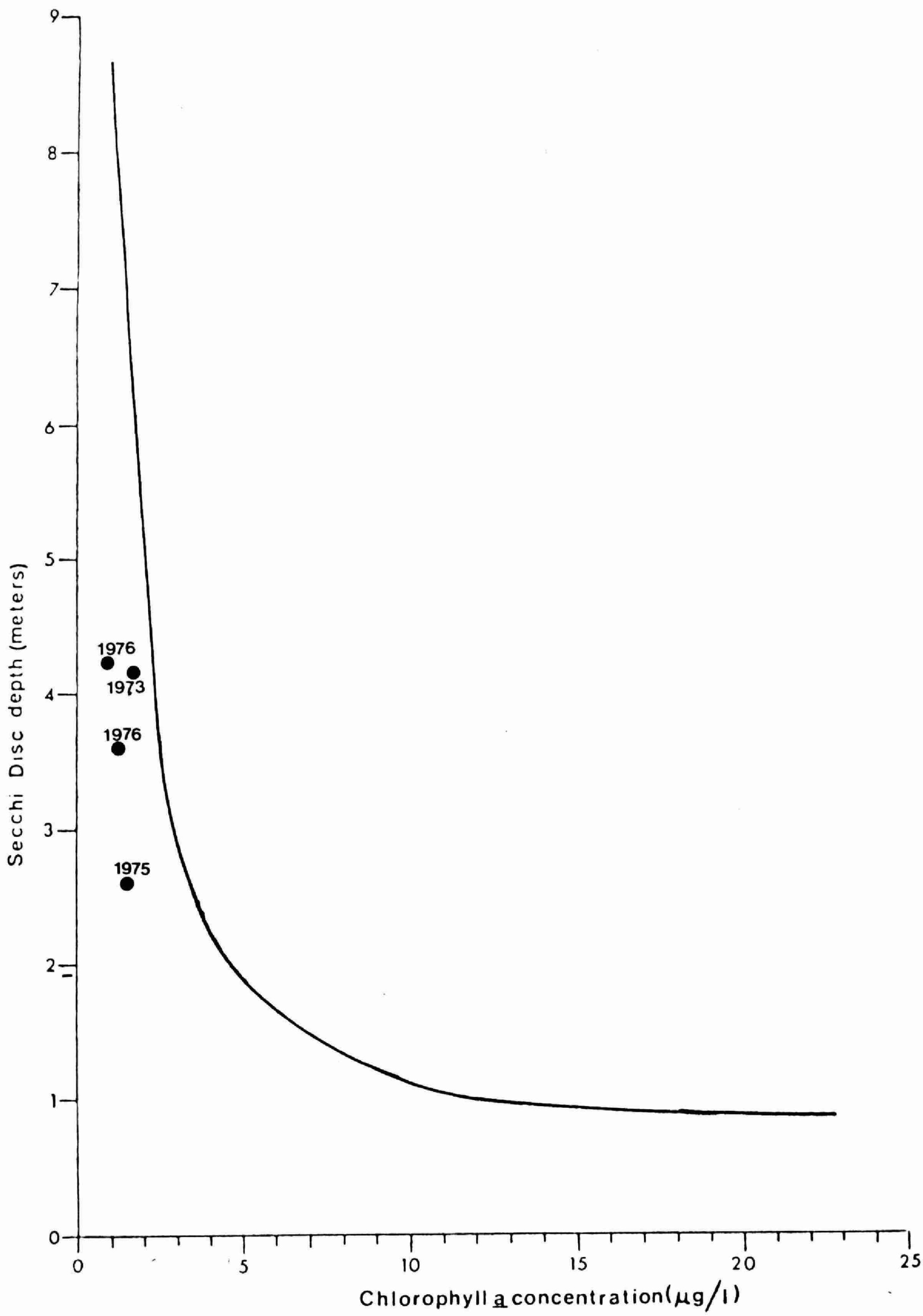

Figure 7– McCullough Lake

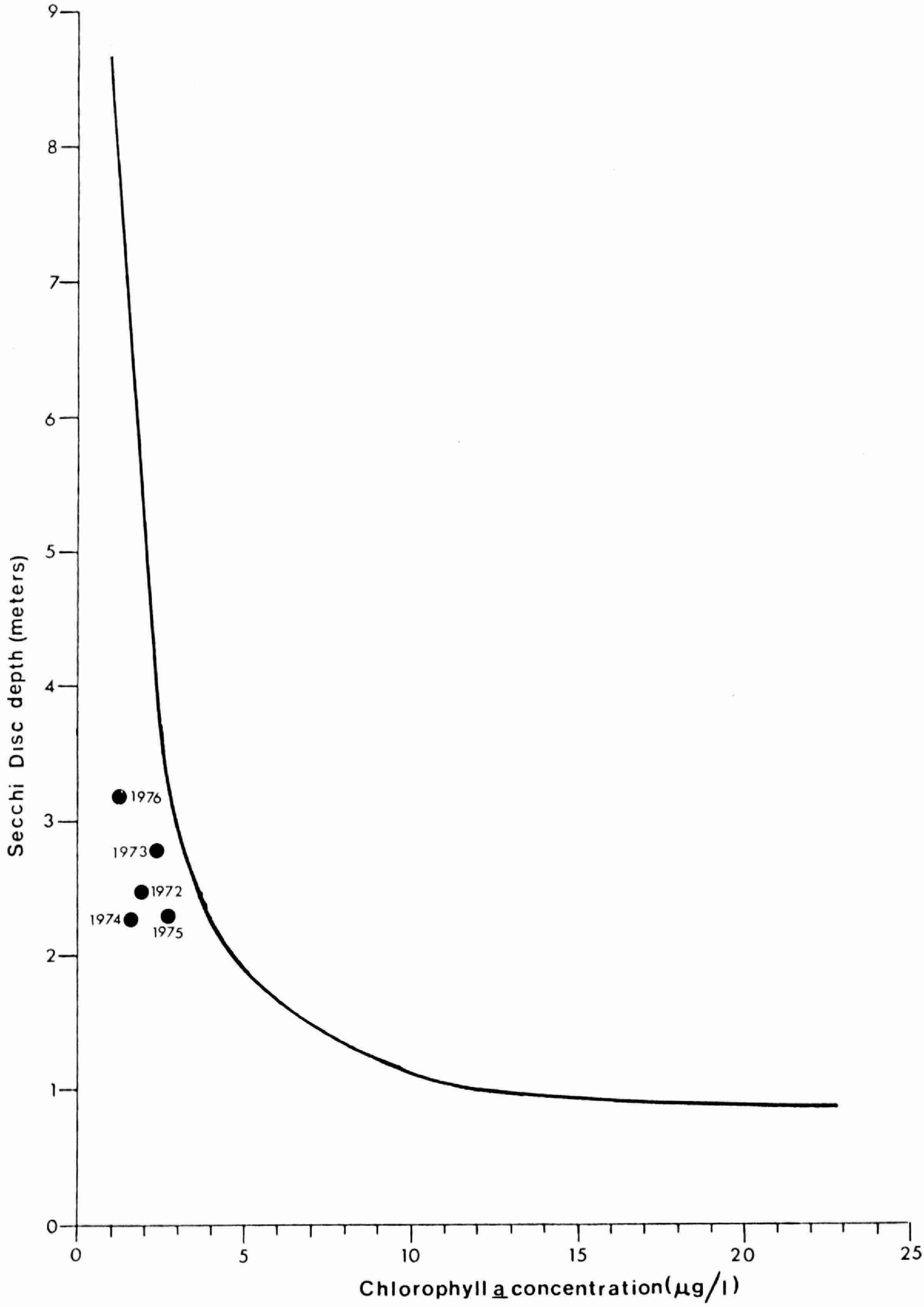

Figure 8 – Miller Lake

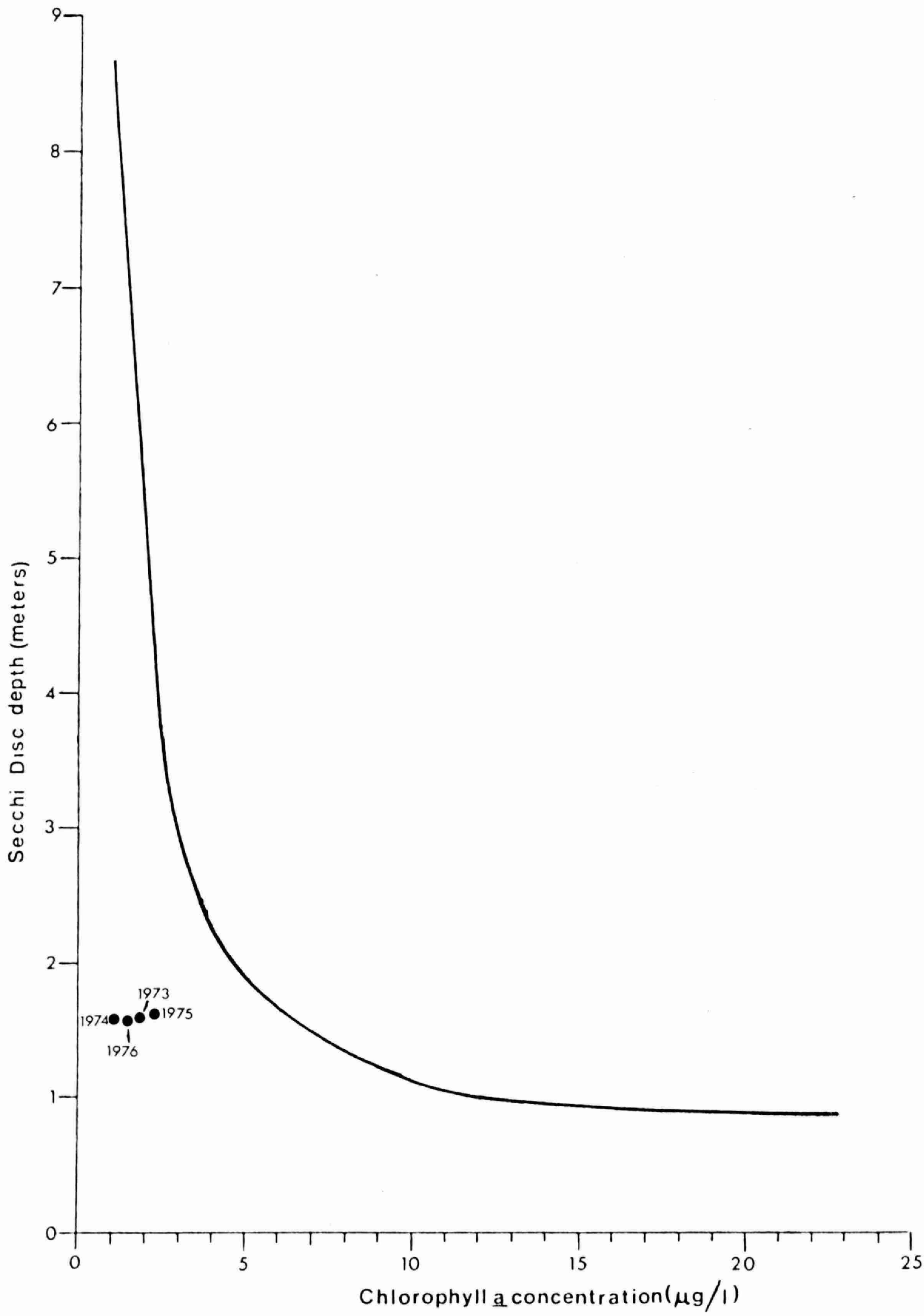

Figure 9 - Sky Lake

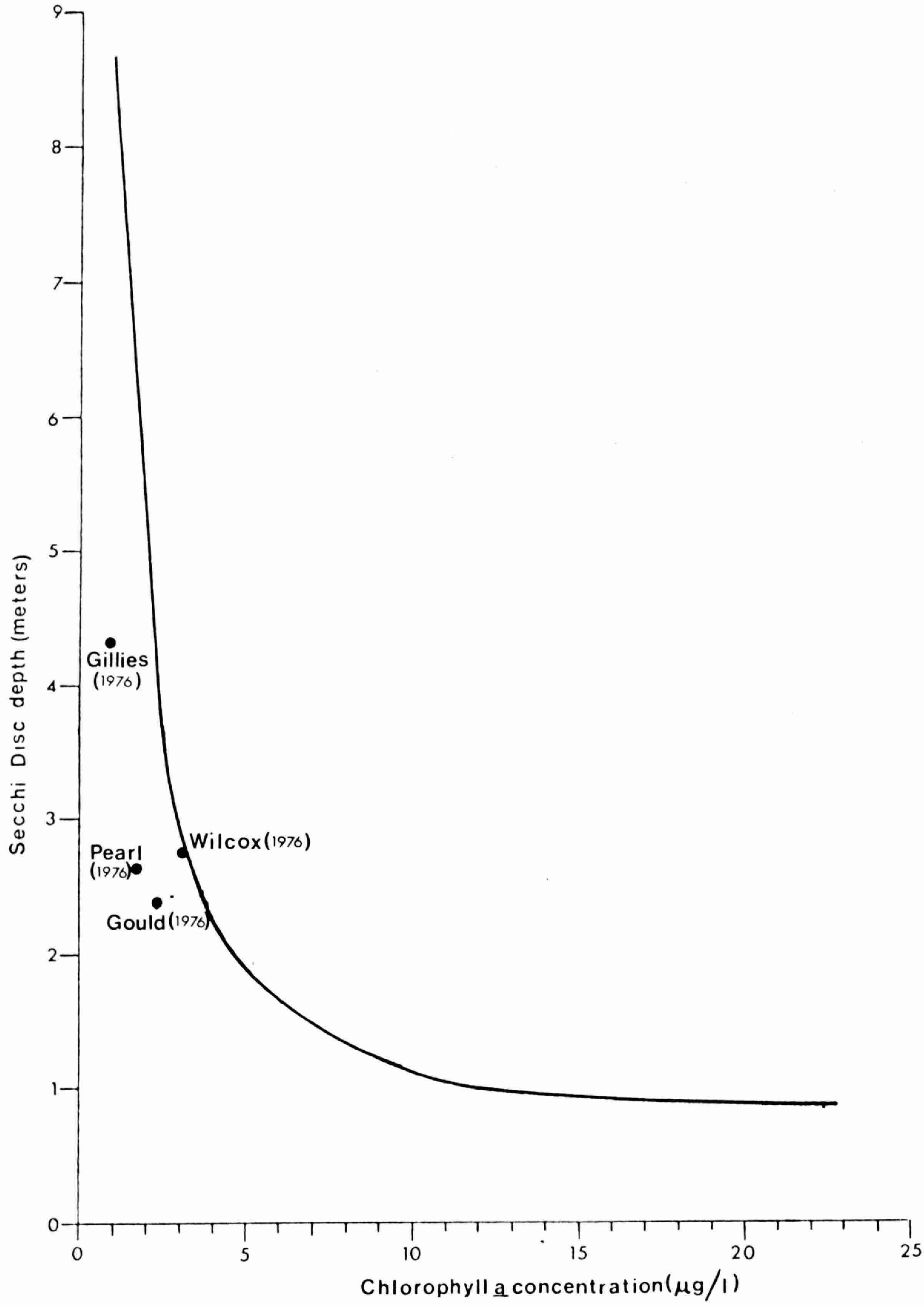

Figure 10 - Gillies,Gould, Pearl and Wilcox Lakes

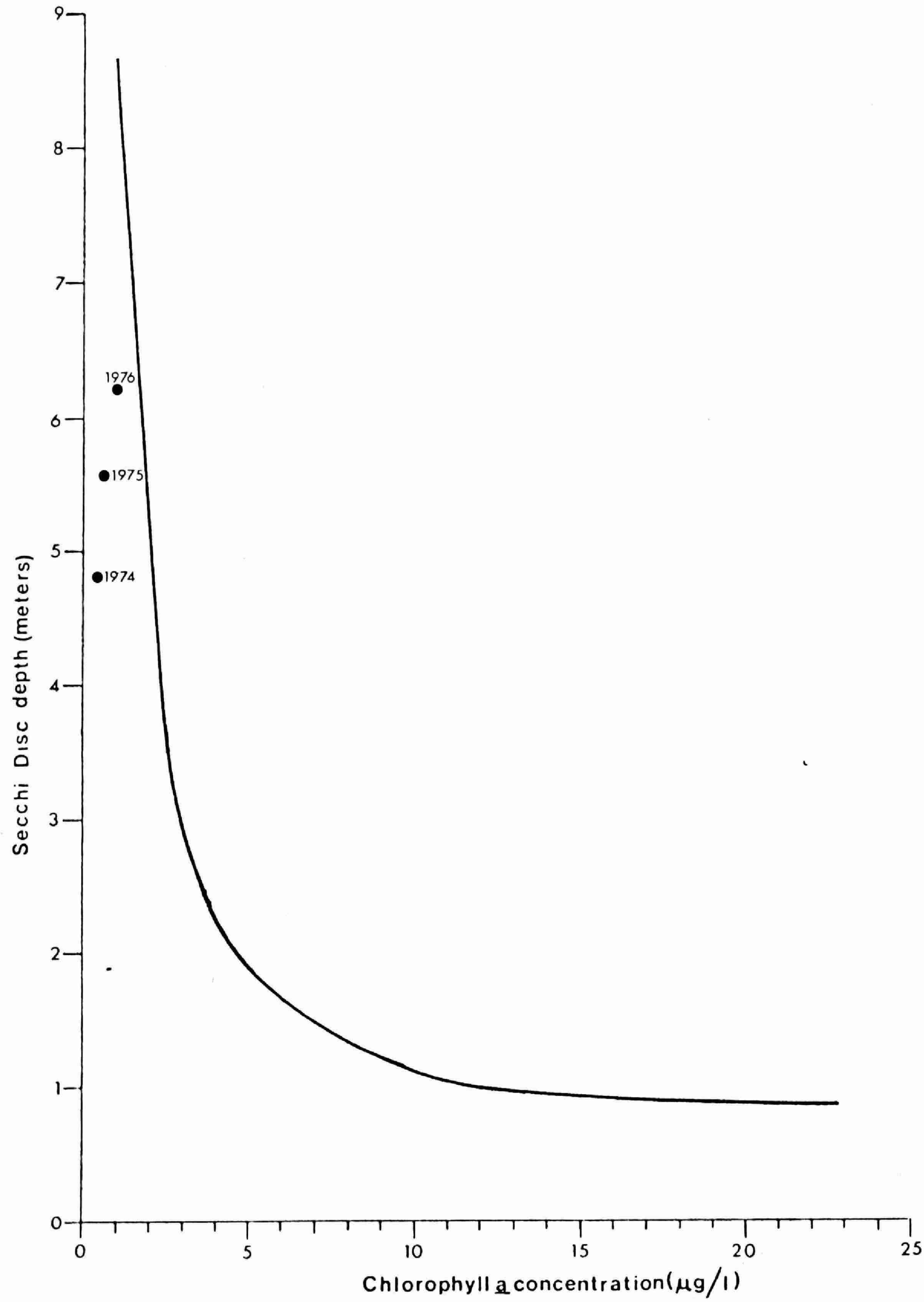

Figure 11 – Owen Sound Bay

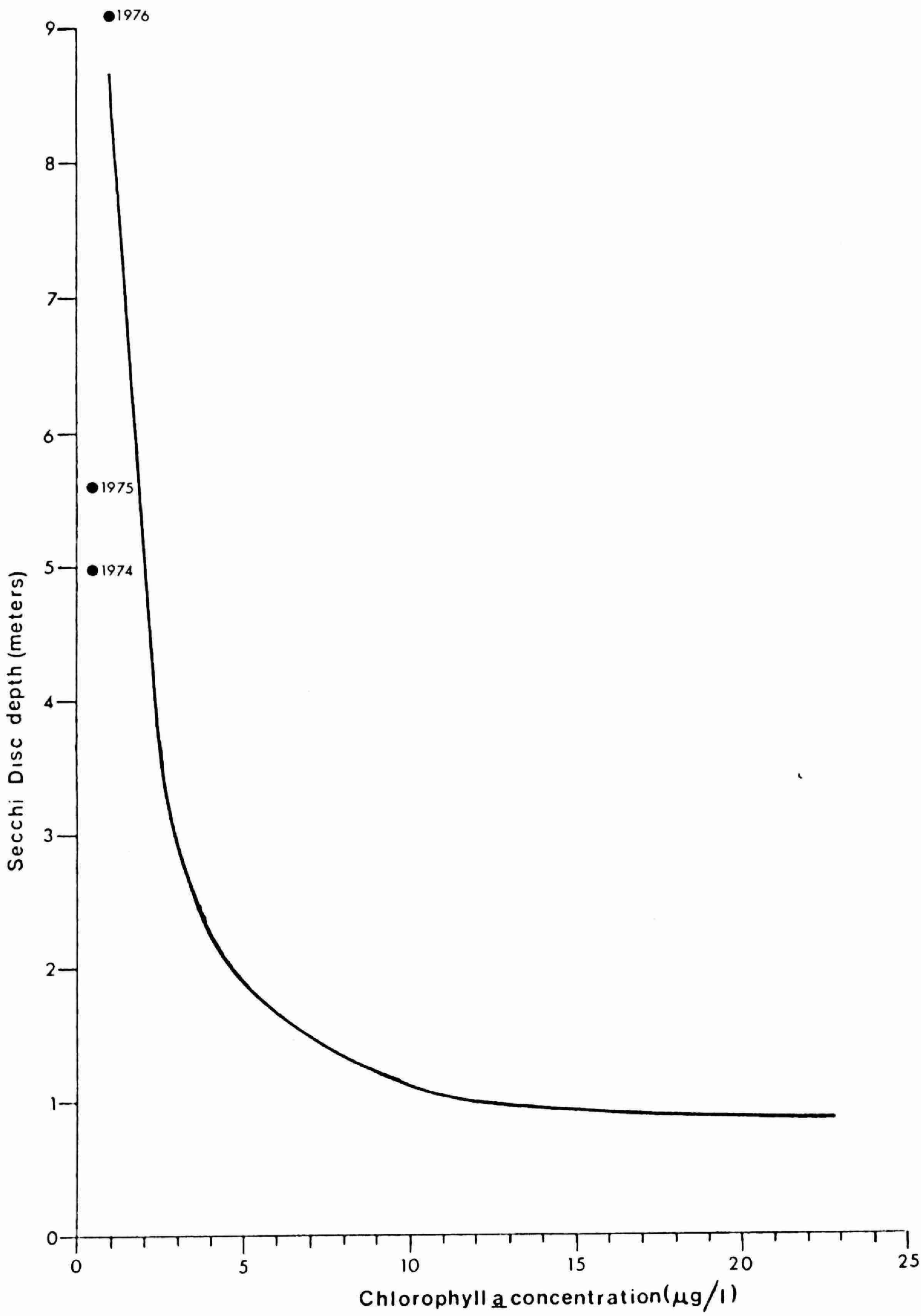

Figure 12 – Tobermory Harbour

APPENDIX C

Information of general interest to cottagers

MICROBIOLOGY OF WATER

For the sake of simplicity, the micro-organisms in water can be divided into two groups. The first group includes the bacteria that thrive in the lake environment and makes up the natural bacterial flora, while the second group is comprised of the dease-causing micro-organisms (pathogens) that have acquired the capability to infect human tissues.

The pathogens are generally introduced into the aquatic environment by raw or inadequately treated sewage, although a few are found naturally in the soil. The presence of these bacteria does not change the appearance of the water but poses an immediate public health hazard if the water is used for drinking or swimming. The health hazard does not necessarily mean that the water user will contract serious water-borne infections such as typhoid fever, polio or hepatitis, but he may catch less serious infections of gastroenteritis (stomach flu), dysentery or diarrhea. Included in these minor afflictions are eye, ear and throat infections that swimmers encounter every year and the more insidious but seldom diagnosed, subclinical infections usually associated with several water-borne viruses. These viral infections leave a person feeling not well enough to enjoy holidaying although not bedridden. This type of microbial pollution can be remedied by preventing untreated wastes from reaching the lake. Water quality will return to satisfactory conditions within a relatively short time (approximately 1 year) since disease causing bacteria usually do not thrive in an aquatic environment.

Natural bacterial flora live and thrive within the lake environment and these organisms are the instruments of biodegradation. Any organic matter in the lake will be used as food by these organisms and will give rise in turn to subsequent increases in their numbers. Natural organic matter as well as organic components from sewage, kitchen wastes, oil and gasoline are readily attacked by these lake bacteria. Unfortunately, biodegradation of the organic wastes by organisms uses correspondingly large amounts of the dissolved oxygen. If the organic matter content of the lake becomes high enough, these bacteria will deplete the dissolved oxygen supply in the bottom waters and threaten the survival of many deep-water fish species.

RAINFALL AND BACTERIA

The "rainfall effect" relates to a phenomenon that has been documented in previous surveys of recreational lakes. Heavy precipitation has been shown to flush the land area around the lake and the subsequent runoff will carry available contaminants including sewage organisms as well as natural soil bacteria with it into the water.

Total coliforms, fecal coliforms and fecal streptococci, as well as other bacteria and viruses which inhabit human waste disposal systems, can be washed into the lake. Where there is inadequate soil cover in areas of the Canadian Shield and in areas of fractured limestone where fissures in the rocks provide access to the lake, this phenomenon is particularly evident.

Melting snow provides the same transportation function for bacteria, especially in an agricultural area where manure spreading is carried out in the winter on top of the snow.

Previous data from sampling points situated 50 to 100 feet from shore indicate that contamination from shore generally shows up within 12 to 48 hours after a heavy rainfall.

WATER TREATMENT

Lake and river water is open to contamination by man, animals and birds (all of which can be carriers of disease); consequently, NO RIVER OR LAKE WATER MAY BE CONSIDERED SAFE FOR HUMAN CONSUMPTION without prior treatment, including disinfection. Disinfection is especially critical if coliforms have been shown to be present.

Disinfection can be achieved by:

(a) Boiling
Boil the water for a minimum of five minutes to destroy the disease causing organisms.

(b) Chlorination using a household bleach containing 4 to 4¼% available chlorine.
Eight drops of a household bleach solution should be mixed with one gallon of water and allowed to stand for 15 minutes before drinking.

(c) Continuous Chlorination
For continous waterdisinfection, a small domestic hypochlorinator (sometimes coupled with activated charcoal filters) can be obtained from a local plumber or water equipment supplier.

(d) Well Water Treatment
Well water can be disinfected using a household bleach (assuming strength of 5% available chlorine) if the depth of water and diameter of the well are known.

Quantity of Chlorine Bleach Per 10 ft. Depth of Water

Diameter of Well Casing in Inches	One to Ten Coliforms	More than Ten Coliforms
4	.5 oz.	1 oz.
6	1 oz.	2 oz.
8	2 oz.	4 oz.
12	4 oz.	8 oz.
16	7 oz.	14 oz.
20	11 oz.	22 oz.
24	16 oz.	31 oz.
30	25 oz.	49 oz.
36	35 oz.	70 oz.

Allow about six hours of contact time before using the water.

Another bacteriological sample should be taken after one week of use.

Water sources (spring, lake, well, etc.) should be inspected for possible contamination routes (surface soil, runoff following rain and seepage from domestic waste disposal sites). Attempts at disinfecting the water without removing the source of contamination will not supply bacteriologically safe water on a continuing basis.

There are several types of low cost filters (ceramic, paper, carbon, diatomaceous earth sometimes impregnated with silver, etc.) that can be easily installed on taps or in water lines. These may be useful in removing particles, if the water is periodically turbid, and are usually very successful. Filters, however, do not disinfect water but may reduce bacterial numbers. For safety, chlorination of filtered water is recommended.

SEPTIC TANK INSTALLATIONS

In Ontario provincial law requires under Part VII of the Environmental Protection Act that before one extends, alters, enlarges or establishes any building where a sewage system will be used, a Certificate of Approval must be obtained from the Ministry of the Environment or its representatives. The local municipality or Health Unit may be delegated the authority to issue the Certificate of Approval. Any other pertinent information such as size, types and location of septic tanks and leaching beds can also be obtained from the same authority.

(i) General Guidelines

A septic tank should not be closer than:

- 50 feet to any well, lake stream, pond, spring, river or reservoir
- 5 feet to any building
- 10 feet to any property boundary

The leaching bed should not be closer than:

- 100 feet to the nearest dug well
- 50 feet to a drilled well which has a casing to 25 feet below ground
- 25 feet to a building with a basement that has a floor below the level of the tile in the leaching bed
- 10 feet to any other building
- 10 feet to a property boundary
- 50 feet to any lake, stream, pond, spring, river or reservoir.

The ideal location for a leaching bed is in a well drained, sandy loam soil remote from any wells or other drinking water sources. For the leaching bed to work satisfactorily, there must be at least 3 feet of soil between the bottom of the leaching tile trenches and the top of the ground water table or bedrock.

DYE TESTING OF SEPTIC TANK SYSTEMS

There is considerable interest among cottage owners to dye test their sewage systems, however, several problems are associated with dye testing. Dye would not be visible to the eye from a system that has a fairly direct connection to the lake. Thus, if a cottager dye-tested his system and no dye were visible in the lake, it may be assumed that the system was satisfactory, which might not be the case. A low concentration of dye is not visible and therefore expensive equipment such as a fluorometer is required. Only qualified people with adequate equipment are capable of assessing a sewage system by using dye. In any case, it is likely that some of the water from a septic tank system will eventually reach the lake. The important questions is whether or not all contaminants including nutrients have been removed before it reaches the lake. To answer this question special knowledge of the system, soil depth and composition, geology and groundwater characteristics of the region is required. Therefore, we recommend that this type of study should be performed only by qualified professionals.

BOATING AND MARINA REGULATIONS

In order to help protect the lakes and rivers of Ontario from pollution, it is required by law that sewage (including garbage) from all pleasure craft, including house-boats, must be retained in suitable equipment. Equipment which is considered suitable by the Ministry of the Environment includes (1) retention devices with or without re-circulation which retain all toilet wastes for disposal ashore and (2) incinerating devices which reduce all sewage to ash.

Equipment for storage of toilet waste shall:

1. be non-portable
2. be constructed of structurally sound material
3. have adequate capacity for expected use
4. be properly installed, and

5. be equipped with the necessary pipes and fittings conveniently located for pump-out by shore-based facilities (although not specified, a pump-out deck fitting with 1½-inch diameter National Pipe Thread is commonly used).

An Ontario regulation requires that marinas and yacht clubs provide or arrange pump-out service for the customers and members who have toilet-equipped boats. In addition, all marinas and yacht clubs must provide litter containers that can be conveniently used by occupants of pleasure boats.

The following "Tips" may be of assistance to you in boating:

1. Motors should be in good mechanical condition and properly tuned.

2. When a tank for outboard motor testing is used, the contents should not be emptied into the water.

3. If the bilge is cleaned, the waste material must not be dumped into the water.

4. Fuel tanks must not be overfilled and space must be left for expansion if the fuel warms up.

5. Vent pipes should not be obstructed and fuel needs must be dispensed at a correct rate to prevent "blow-back".

6. Empty oil cans must be deposited in a leak-proof receptacle, and

7. Slow down and save fuel.

EUTROPHICATION (NUTRIENT ENRICHMENT) AND LAKE PROCESSES

In recent years, cottagers have become aware of the problems associated with nutrient enrichment of recreational lakes and have learned to recognize many of the symptoms characterizing nutrient enriched (eutrophic) lakes. It is important to realize that small to moderate amounts of aquatic plants and algae are necessary to maintain a balanced aquatic environment. They provide food and a suitable environment for the growth of aquatic invertebrate organisms which serve as food for fish. Shade from large aquatic plants helps to keep the lower water cool, which is essential to certain species of fish and also provides protection for young game and forage fish. Numerous aquatic plants are utilized for food and/or protection by many species of waterfowl. However, too much growth creates an imbalance in the natural plant and animal community particularly with respect to oxygen conditions, and some desirable forms of life such as sport fish are eliminated and unsightly algal scums can form. The lake will not be "dead" but rather abound with life which unfortunately is not considered aesthetically pleasing. This change to poor water quality becomes apparent after a period of years during which extra nutrients have been added to the lake. Return to the natural state may also take a number of years after the nutrient inputs are regulated.

Changes in water quality with depth are a very important characteristic of a lake. Water temperatures are uniform throughout the lake in the early spring and winds generally keep the entire volume well mixed. Shallow lakes may remain well mixed all summer so that water quality will be the same throughout. On the other hand, in deeper lakes, the surface waters warm up during late spring and early summer and float on the cooler more dense water below. The difference in density offers a resistance to mixing by wind action and many lakes do not become fully mixed again until the surface waters cool down in the fall. The bottom water receives no oxygen from the atmosphere during this unmixed period and the dissolved oxygen supply may be depleted by bacteria as they decompose organic matter. Cold water fish, such as trout, will have to move to the warmer surface waters to get oxygen and because of the high water temperatures they will not thrive, so that the species will probably die out (Figure C-1).

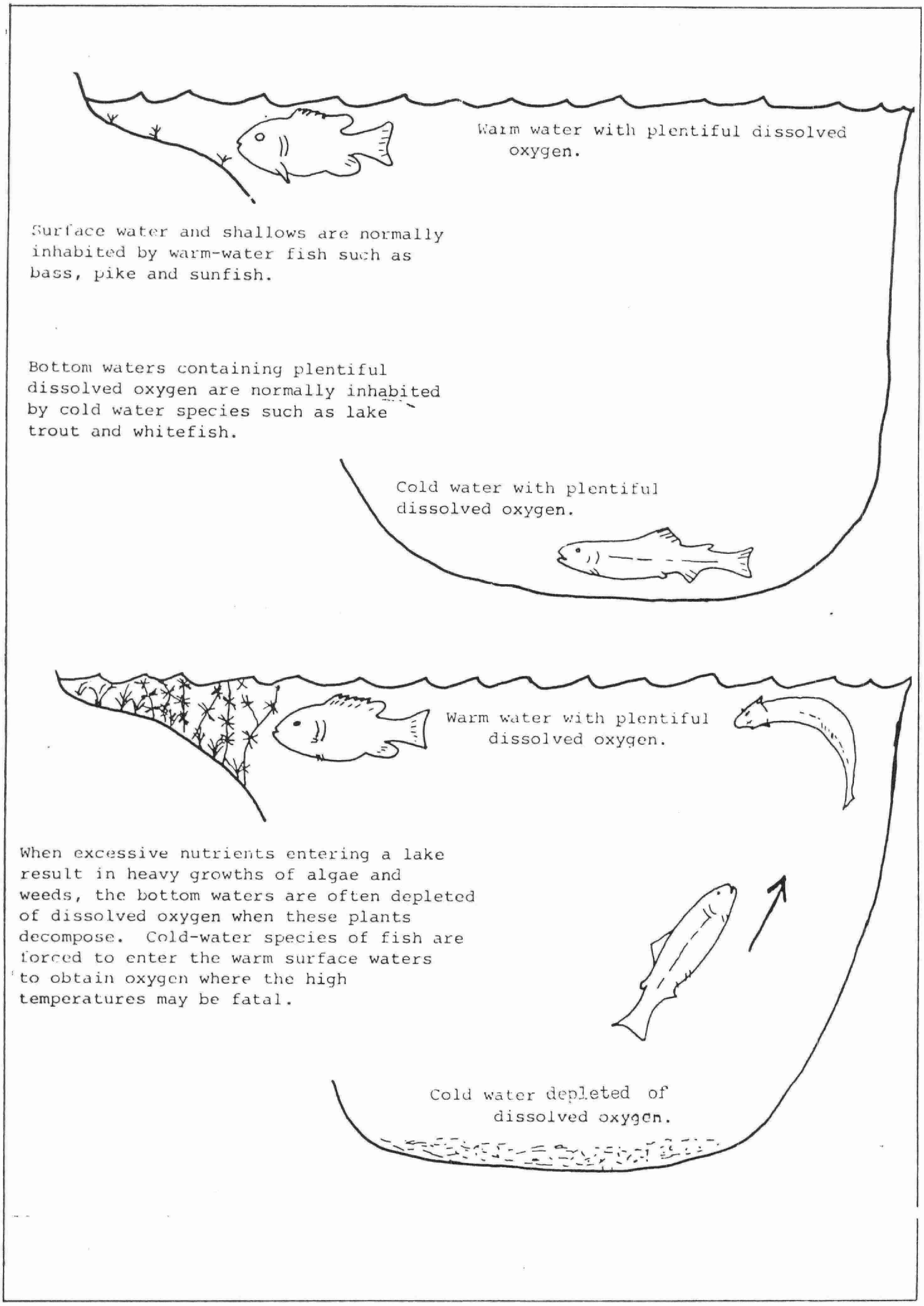

FIGURE C-1 Decomposition of plant matter on a lake bottom and the effect on fish.

Low dissolved oxygen conditions in the bottom waters are not necessarily an indication of pollution but excessive aquatic plant and algae growth and subsequent decomposition in the bottom waters can aggravate the condition and in some cases result in zero oxygen levels in lakes which had previously held some oxygen in the bottom waters all summer. Although plant nutrients normally accumulate in the bottom waters of lakes, they do so to a much greater extent if there is no oxygen present. These nutrients become available for algae in the surface waters when the lake mixes in the fall and dense algae growths can result. Consequently, lakes which have no oxygen in the bottom water during the summer are more prone to having algae problems and more vulnerable to nutrient inputs than lakes which retain some oxygen.

Like humans, aquatic plants and algae require a balanced "diet" for growth. Other special requirements including those for light and temperature are specific for certain algae and plants. Chemical elements such as nitrogen, phosphorus, carbon, and several others, are required and must be in forms which are available for uptake by plants and algae. Growth of algae can be limited by scarcity of any single "critical" nutrient. Nitrogen and phosphorus are usually considered "critical" nutrients because they are most often in scarce supply in natural waters, particularly in lakes in the Precambrian areas of the Province. Phosphorus, in particular is necessary for the processes of photosynthesis and cell division. Nitrogen and phosphorus are generally required in the nitrate-N (or ammonia-N) and phosphate forms and are present in natural land runoff and precipitation. Human and livestock wastes are a very significant source of these and other nutrients for lakes in urban and agricultural areas. IT IS EXTREMELY IMPORTANT THAT COTTAGE WASTE DISPOSAL SYSTEMS FUNCTION PROPERLY SO THAT EXCESSIVE QUANTITIES OF NUTRIENTS ARE NOT RELEASED TO THE LAKE since the changes in water quality brought about by excessive inputs of nutrients to lakes are usually evidenced by excessive growths of algae and aquatic plants.

The large amounts of suspended algae which materialize from excessive inputs of nutrients, result in turbid water of poor clarity or transparency. On the other hand, lakes with only small, natural inputs of nutrients and correspondingly low nutrient concentrations (characterisically larger and deeper lakes) most often support very small amounts of suspended algae and consequently are clear-water lakes. An indication of the degree of enrichment of lakes can therefore be gained by measuring the density of suspended algae (as indicated by the chlorophyll

a concentration - the green pigment in most plants and algae) and water clarity (measured with a Secchi disc). In this regard staff of the Ministry of the Environment have been collecting chlorophyll *a* and water clarity data from several lakes in Ontario and have developed a graphical relationship between these parameters (Figure 2) which is being used by cottagers to further their understanding of the processes and consequences of nutrient enrichment.

In the absence of excessive coloured matter (eg. drainage from marshlands), lakes which are very low in nutrients are generally characterized by small amounts of suspended algae (ie. chlorphyll *a*) and are clear-water lakes with high Secchi disc values. Such lakes, with chlorophyll *a* and Secchi disc values lying in the upper lefthand area of the graph are unenriched or nutrient-poor ("oligotrophic") in status and do not suffer from the problems associated with excessive inputs of nutrients. In contrast, lakes with high chlorophyll *a* concentrations and poor clarity are positioned in the lower right-hand area of the graph and are enriched ("eutrophic"). These lakes usually exhibit symptoms of excessive nutrient enrichment including water turbidity owing to large amounts of suspended algae which may float to the surface and accumulate in sheltered areas around docks and bays.

Measurements of suspended algal density (chlorophyll *a*) and water clarity are especially valuable if carried out over several years. Year-to-year positional changes on the graph can then be assessed to determine whether or not changes in lake water quality are materializing so that remedial measures can be implemented before conditions become critical.

PROS AND CONS OF AQUATIC VEGETATION

Higher aquatic plants and algae are important in maintaining a balanced aquatic environment. However, depending on the uses made of the water, there may be situations where their presence in excessive amounts is undesirable.

On the positive side, in addition to maintaining an oxygen balance essential to fish life, water plants provide a suitable environment for the production of aquatic invertebrate organisms which serve as food for fish. They also contribute to keeping water temperatures at the low levels essential to certain species of fish and they provide shade and protection for young game fish and forage fish species. Finally, numerous aquatic plants are utilized for food and/or protection by many species of waterfowl.

On the other hand, ponds and lakes may become unsightly because of the presence of dense mats of decomposing surface-type algae. Recreational uses such as fishing, swimming or boating may be impaired by heavy accumulations of algae or thick growths of higher aquatic plants. Decaying masses of vegetation may cause water to become less palatable to humans or to domestic livestock. Finally, winter-kills of fish may result from oxygen depletion in the water caused by a decomposition of plants under the ice during certain winter conditions.

Certainly, a careful assessment of the various usages and relative values of the presence or absence of aquatic plants in a particular situation should be made before any control project is undertaken.

CONTROL OF AQUATIC PLANTS

Temporary control of aquatic plants may be achieved by either mechanical or chemical means. Raking and chain dragging operations have often been used in the past for controlling submerged rooted aquatics in small areas. Since floating plant fragments may develop roots and grow elsewhere or wash onshore and decompose, cutting the vegetation without removing cut material from the water often acts to spread the problem. On a large scale, underwater harvesting and dredging machines may be used successfully to keep channels open for boating and to provide access to docks and good fishing areas; however, the cost and maintenance of this equipment is prohibitive for individual cottagers. Aquatic vegetation harvesting at present is still under experimental study in the province and thus is not recommended for public use. Shoreline emergent plants should be hand-pulled or cut with a scythe when the area involved is not too large.

To develop a small swimming area, dark heavy-duty construction polyethylene can be placed on the lake bottom to prevent weed growth. In sheltered areas of a lake, this can be accomplished by placing the sheet of plastic on the ice in late winter and weighing it down with sand, gravel and small stones. Several small air holes should be punctured in the plastic to allow gases that form on the lake bottom to escape. Once the plastic has settled to the bottom, it can be covered with additional sand. Reports by individuals who have used this technique indicate great variability in its success. Wave action and traffic over poorly weighted plastic have caused it to shift and sometimes tear. Plants may also grow through the air holes or re-establish after a period of years on the overlying substrate, particularly if the sand contains organic matter.

Other methods of vegetation control are being investigated which largely involve habitat alteration to discourage plant growth. In ponds and reservoirs where water levels may be manipulated, a full or partial draw down in the fall allows the plants to freeze and when the depression is filled in the spring, re-establishment of the plant community must occur before vegetation will again be a problem. Removal or dilution of plant and algal nutrients in the water by alum precipitation or increased flushing are also techniques under study for their suitability in aquatic vegetation management.

Chemical methods can also be used to control submergent vegetation. However, the herbicides and algicides currently available generally provide control for a period of several weeks to a single season. A satisfactory algicide or herbicide must kill or stunt the plant or plants causing a nuisance at reasonable cost without affecting fish or other aquatic life. At the present time there is no one chemical which will adequately control all species of algae and other aquatic plants.

In selecting a particular chemical, the species for which control is desired must be considered, as well as the temperature and chemical properties of the water. If the vegetation is not properly identified, the incorrect pesticide may be used, and no control achieved.

Prior to undertaking a treatment, the need for chemical control should be weighed carefully in light of alternative mechanical methods. When chemical treatment is preferable, all instructions provided should be followed exactly to minimize any possible detrimental affects to the environment.

Chemical treatment of large areas of submerged aquatic vegetation have been known to promote development of nuisance algal blooms, particularly blue-greens following decomposition of plant material and nutrient release. These algae may present an even greater problem in terms of taste, odour, and reduced water clarity than the original problem. Therefore only small areas of water of high recreational priority should be selected for chemical treatment.

Guidelines and summaries of control methods, and applications for permits are available from the Pesticides Control Section, Pollution Control Branch, Ministry of the Environment, 1 St. Clair Avenue West, Toronto, Ontario, or your nearest District Pesticides Officer.

CONTROL OF BITING INSECTS

Mosquitos and blackflies often interfere with the enjoyment of recreational facilities at the lake-side vacation property. Pesticidal spraying or fogging in the vicinity of cottages produces extremely temporary benefits and usually does not justify the hazard involved in contaminating the nearby water. Erradication of biting fly populations is not possible under any circumstances and significant control is rarely achieved in the absence of large-scale abatement programmes involving substantial funds and trained personnel. Limited use of approved larvicides in small areas of swamp or in rain pools close to residences on private property may be undertaken by individual landowners, but permits are necessary wherever treated waters may contaminate adjacent streams or lakes. The use of repellents and light traps is encouraged, as are attempts to reduce mosquito larval habitat by improving land drainage. Applications for permits to apply insecticides as well as technical advice can be obtained from the Pesticides Control Section, Pollution Control Branch, Ministry of the Environment, 1 St. Clair Avenue West, Toronto, Ontario, or your nearest District Pesticides Officer.